JULY, 1953 RESEARCH BULLETIN 525

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
J. H. Longwell, *Director*

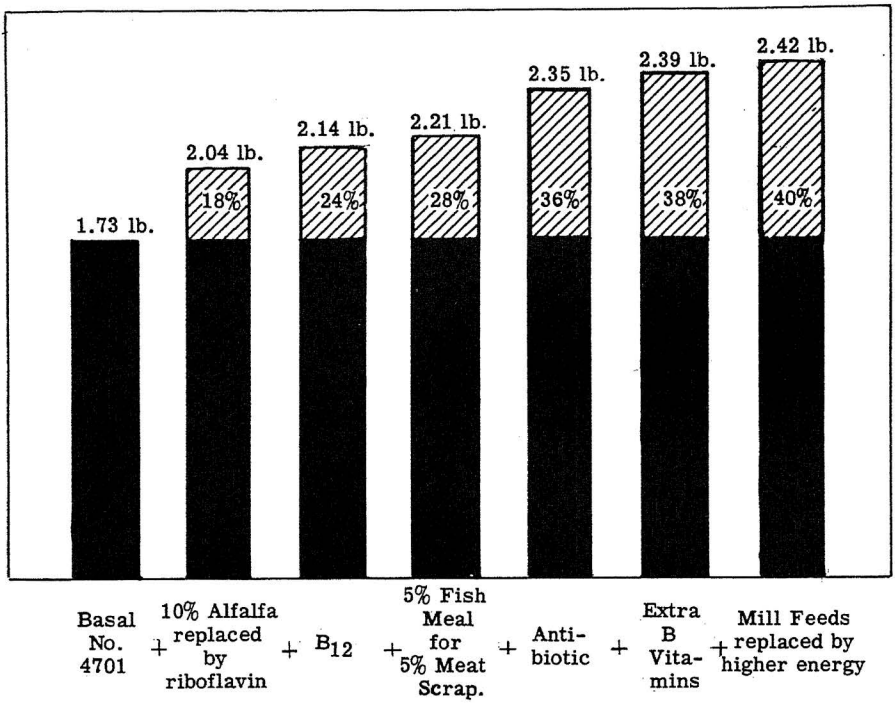
Experiments in Chick Feeding 1947-1952

Q. B. KINDER AND H. L. KEMPSTER

(Publication authorized June 10, 1953)

COLUMBIA, MISSOURI

GROWTH RATE IN BATTERIES TO 8 WEEKS AS AFFECTED BY CHANGES IN BASAL RATION



Cumulative increase in growth rate of broiler type chicks due to additions and substitutions in Basal Ration.

This bulletin is a report on Department of Poultry Husbandry research project No. 24, entitled "Rations for Growing Chicks."

Experiments in Chick Feeding 1947-1952

Q. B. Kinder and H. L. Kempster

INTRODUCTION

Progress in nutritional research has been extremely rapid in recent years. Basic research has revealed new vitamins, determined optimum levels of essential amino acids, studied effect of energy level on growth rate, and disclosed growth promoting properties of non-nutritional factors such as antibiotics. Application of the findings of basic research to practical poultry rations can be accomplished only through extensive testing, using natural feed ingredients properly supplemented with needed vitamins, minerals, amino acids, and other growth promoting factors.

The phenominal growth of the broiler industry has given added incentive to build rations that will give more rapid growth and higher feed efficiency. Progress has been very rapid. Broiler producers today are producing a 3-pound broiler in 8½ to 10½ weeks with a feed efficiency of 2.8 to 3.3 pounds feed per pound gain. Fifteen years ago it was considered normal if broilers weighed 3 pounds at 12-14 weeks of age and required 4 to 4½ pounds of feed to produce a pound of gain. Some of this improvement has been due to the breeding of faster growing meat strains of birds, but much of it has been due to improved nutrition.

To understand these new developments and their application, it is necessary to test many rations and make a careful analysis or study of work that has been done. Although the performance of a ration can be predicted with fair accuracy, the final evaluation of any formula must depend on feeding trials under controlled conditions. The following report on feeding trials offers opportunity to follow changes, growth, and development of many new findings in nutrition. These changes include use of synthetic sources of riboflavin and Vitamin B_{12}, evaluation of growth promoting properties of various proteins, relation of fiber and energy level of rations to growth rate, and effect of antibiotics on growth rate and feed efficiency in young chicks.

METHODS AND EQUIPMENT

Procedure. Each year a series of 8 to 10 rations were designed to apply findings of basic research to practical chick rations. Battery tests were run to 8 weeks of age and chick weights and feed efficincy taken at 4-week intervals. Chicks were started in electrically heated battery brooders; replications

of each lot were arranged to avoid any bias due to location. All chicks had uniform floor space, light, heat, feed, and water conditions. Two tests, one in the fall and one in the spring, were run on each series of rations with two replications of 25 chicks per lot, making a total of 100 chicks on each series of rations. Following completion of the two battery tests each year, three or four rations were selected from the original group and tested under floor brooding conditions in 10 ft. x 12 ft. pens of a long brooder house. Two replications of 100-120 straight run chicks were used in these tests. Growth rate and feed efficiency were measured at 4 to 8 weeks.

Source of Chicks. Although a wide variety of chicks were used over the 5-year period, chicks within a given series or replication were of the same breeding. Dual purpose type New Hampshires and White Rocks from the University farm flock and commercial broiler strains of New Hampshires and crosses made up the bulk of the chicks. Some White Leghorn x heavy breed cross males were used. Each experiment designates breed and sex of chicks used. Care was taken to avoid bias in sampling. Chicks were wing banded when one day old. Individual weights were usually taken. Where straight run chicks were used, the 4-week weight is the average of all chicks, whereas, the 8-week weight is the average male weight plus the average female weight divided by two.

Preparation of Rations. Rations were compounded by using standard feed ingredients from commercial firms, carefully weighed and mixed in 200 pound lots in a small feed mixer. Small quantity ingredients such as crystalline riboflavin were premixed in a gallon jar with soybean oil meal to which a small amount of feed oil had been added. The first two numbers of the ration designate the year in which it was used.

Objectives of Tests. Discovery that much of the value of alfalfa meal and dried milk in chick rations is due to riboflavin content, and the current availability of economical sources of synthetic riboflavin permit a re-evaluation of the role of alfalfa meal, milk products, meat and bone scrap, and fish meal in chick nutrition. Continued expansion of soybean production makes soybean oil meal one of the most readily available and economical proteins for chicks, provided it is properly supplemented with minerals, vitamin B_{12} and riboflavin. A protein level of about 20 percent has been fairly well established as the most economical level in rations for chicks up to 8 weeks of age. Broiler production has emphasized need for rapid growth and feed efficiency. Experimental work on the best balance of proteins, proper energy levels in rations, and the utilization of economical sources of B_{12} and riboflavin appear to point the way to increased feed efficiency and cheaper feed cost per pound of gain.

EFFECT OF ALFALFA MEAL, TYPE OF PROTEIN, SOURCE OF RIBOFLAVIN, ADDITION OF IODINATED CASEIN ON CHICK GROWTH AND FEED EFFICIENCY

Due to the similarity of objectives with Series A and B in Tables 1 and 2, their results will be summarized and discussed together. Since the two series are in complete accord, the increased number of feeding trials add greater significance to results and conclusions. These series were designed to:

(1) Study the effect of level of alfalfa meal in rations on chick growth and feed efficiency.

(2) Evaluate various protein supplements for chick rations.

(3) Compare riboflavin from synthetic sources to that occuring in natural feedstuffs of alfalfa meal and dried milk.

(4) Study the effect of iodinated casein on growth and feathering of young chickens.

(5) Compare wheat mill feedstuffs to ground wheat in chick rations.

Complete rations with calculated analysis and results are given in Tables 1 and 2. Use of a rather wide variety of rations complicates analysis

Table 1, Series A, 1947 - Effect of Alfalfa Meal, Dried Milk and Synthetic Riboflavin on Growth Rate of Chicks.

Ration Number	4701	4702	4703	4704	4705	4706	4707
	Per cent or pounds per 100# except where indicated						
Yellow Feed Meal	46.0	49.0	51.5	49.0	49.0	51.2	51.2
Wheat Shorts	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Bran	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Soybean Meal	15.0	16.5	19.0	16.5	16.5	14.5	14.5
Alfalfa Meal 17%	10.0	5.0	-	5.0	5.0	-	-
Meat and Bone Meal	7.0	5.0	7.5	7.5	7.5	7.5	7.5
Dried Milk	-	2.5	-	-	-	5.0	5.0
Bone Meal	-	.75	1.0	1.0	1.0	.75	.75
Feed Oil (400 D)	.3	.3	.3	.3	.3	.3	.3
Salt	.5	.5	.5	.5	.5	.5	.5
Mn SO_4	.02	.02	.02	.02	.02	.02	.02
Riboflavin mg.	-	50.0	100.0	-	100.0	-	100.0
Calculated Analysis Totals							
Protein %	19.30	19.3	20.1	19.7	19.7	19.9	19.9
Fiber %	5.80	4.72	3.76	4.76	4.76	3.52	3.52
Riboflavin mg.	154.0	192.0	191.0	123.0	222.7	135.0	235.0
Results*							
4 week wt. ave. pounds	.59	.67	.76	.68	.70	.74	.74
8 week wt. ave. pounds	1.73	1.86	2.06	1.92	1.95	2.13	2.11
Feed efficiency 8 wk.	3.06	2.87	2.96	3.04	2.97	2.82	2.90

* Results using 2 replications of 25 straight run dual purpose New Hampshires per lot. (Batteries).

but permits a greater number of comparisons. Due to the design of a given series of rations, the same ration may act as an experimental ration or as a control, depending upon the comparison to be made. For purposes of clarity,

those comparisons that have bearing on the specific point in question have been segregated.

Table 2, Series B Rations--Battery Feed Trials Jan. 1948. Effect of Type Proetin, Level of Alfalfa Meal and Addition of Iodinated Casein on Chick Growth and Feed Efficiency.

Ration No.	4801	4802	4803	4804	4805	4806	4807	4808	4809
	Percent or pounds per 100# except where indicated								
Yellow Corn Meal	46.0	49.0	51.5	51.2	51.5	51.5	52.0	52.0	51.5
Wheat Shorts	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	(20% Gr.)
Wheat Bran	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	(Wheat)
Soybean Oil Meal	15.0	16.5	19.0	14.5	19.0	19.0	26.0	26.0	19.0
Alfalfa Meal	10.0	5.0	-	-	-	-	-	-	-
Meat & Bone Scrap	7.0	5.0	7.5	7.5	2.5	2.5	-	-	7.5
Fish Meal	-	-	-	-	5.0	5.0	-	-	-
Dried Milk	-	2.5	-	5.0	-	-	-	-	-
Bone Meal	-	0.75	1.0	0.75	1.0	1.0	1.5	1.5	1.0
Feed Oil (400 D)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Salt	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0	0.5
Riboflavin mg.	-	100.	100.	-	100.	100.	150.	150.	100.
Mn SO_4	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
I. C. gm. *1	-	-	-	-	-	18.	-	18.	-
Calculated analysis of rations									
Crude Protein %	19.5	19.4	20.2	19.9	20.9	20.9	19.5	19.5	19.4
Total Riboflavin	155.0	215.0	192.0	143.0	198.0	198.0	198.0	198.0	178.0
Net Energy Therms	72.0	73.5	75.2	75.9	75.7	75.7	76.3	76.3	78.0
Fiber %	6.2	4.9	3.9	3.3	3.8	3.8	4.0	4.0	3.3
Results *2									
Ave. Wt. 4 wks. lbs.	.66	.70	.77	.79	.86	.85	.78	.70	.78
Ave. Wt. 8 wks. lbs.	1.73	1.86	2.10	2.10	2.30	2.09	2.09	1.80	2.14
Feed Eff. 8 wks.	3.18	2.87	2.79	2.86	2.57	2.81	2.81	3.21	2.69

*1. Iodinated casein has thyroxin activity of about 3%.
*2. Average of two tests - 50 Delaware x New Hampshire straight run chicks per test on each ration.

Data in Table 3 offers some rather conclusive evidence that alfalfa meal tends to decrease growth rate and feed efficiency. Rations without alfalfa meal were 9.1 percent faster growing than rations with 5 percent alfalfa meal and 16.8 percent faster than rations with 10 percent alfalfa meal. Each 1 percent of alfalfa decreased growth rate about 1.8 percent. Since these rations were all similar, about the same in protein level, and adequate in riboflavin, the depressing effect of alfalfa meal appears to be due to lower energy level of the ration, increased fiber, or a factor(s) in alfalfa meal that depresses growth rate. Decreases in feed efficiency were similar but of less magnitude than growth rate.

Table 3. Effect of Alfalfa Meal on Growth Rate and Feed Efficiency to 8 Weeks.

Ration Number	Alfalfa Meal %	8 week data - Average Series A and B			
		Weight Lbs.	% Dev.	Feed Eff.	% Dev.
4701 & 4801	10	1.73	-16.8	3.12	7.2
4704 & 4802	5	1.89	- 9.1	2.95	1.4
4703 & 4804	0	2.08	0.0	2.91	0.0

Basic ingredients in preceding rations are corn meal, meat scrap, and soybean oil meal. These ingredients are deficient in riboflavin and, without supplementary sources of this vitamin, will result in poor growth and curled toe paralysis. Table 4 compares the effect of supplying needed riboflavin

Table 4. Effect of Source of Riboflavin - Crystalline Riboflavin as Compared to Natural Feed Sources on Growth Rate.

Ration Number	Source of Riboflavin: Alfalfa Meal %	Dried Milk %	Crystalline Riboflavin Mg./100 lbs.	8 week Data: Weight lbs.	Deviations from 4701%
4701	10.0	-	-	1.73	0.0
4703	-	-	100 mg.	2.06	+19.0
4704	5.0	-	-	1.92	+10.9
4705	5.0	-	100 mg.	1.95	+11.3
4706	-	5.0	-	2.13	+23.1
4707	-	5.0	100 mg.	2.10	+21.9

through alfalfa meal or milk with crystalline riboflavin. Disregarding other possible effects of these ingredients, the following conclusions may be drawn.

Although alfalfa meal prevented curled toe paralysis it did not promote rapid growth. Ration 4701 with 10 percent of alfalfa meal was 19 percent under ration 4703 where synthetic or crystalline riboflavin was used. Ration 4704, containing 5 percent alfalfa meal, apparently supplied adequate amounts of riboflavin as the addition of 100 milligrams of crystalline riboflavin per 100 pounds (as in ration 4705) had little additional effect. Chicks on ration 4704 gained 8 percent less than those on ration 4703 which depended on crystalline riboflavin as a supplement.

Dried milk at a 5 percent level in ration 4706 gave good growth rate. Addition of crystalline riboflavin to this type of ration (4707) did not improve growth rate. Dried milk gave an increased growth response of about 2.5 percent above crystalline riboflavin. For rapid growth rate results indicate alfalfa meal is a poor source of riboflavin while dried milk is an excellent source. Crystalline riboflavin can effectively replace alfalfa meal and promote faster growth. It can replace dried milk with little loss in growth rate.

Table 5. Effect of Type of Protein on Growth Rate and Feed Efficiency. (All Rations Adequate in Ribovlavin).

Ration Number	Protein Concentrates %: Soybean Oil Meal	Meat Scrap	Dried Milk	Fish Meal	8 week Data: Weight lbs.	% Deviation	Feed Eff.	% Deviation
4803	19.0	7.5	-	-	2.10	+0.5	2.87	-2.1
4804	14.5	7.5	5.0	-	2.12	+1.4	2.86	-1.7
4805	19.0	2.5	-	5.0	2.30	+10.0	2.57	+8.7
4807	26.0	-	-	-	2.09	0.0	2.81	0.0

If the all soybean oil meal ration (4807) is used as a basal or control ration the following observations may be made.

(1) Ration 4807, an all soybean oil meal protein ration, when supplemented with proper mineral and riboflavin, gave as satisfactory growth rate and feed efficiency as ration 4803 with 19.0 percent soybean meal and 7.5 percent meat scrap.

(2) Adding 5 percent dried milk to a soybean-meat scrap ration (4804) improved growth rate only 1.4 percent over the soybean oil meal ration.

(3) Addition of 5 percent fish meal in ration 4805 gave a 10 percent increase in growth rate and 8.7 percent improved feed efficiency over the basal soybean meal ration. Apparently fish meal contains some factor (s) necessary for maximum growth. One of these factors is B_{12}.

Effect of Iodinated Casein on Growth Rate

Iodinated casein or thyroprotein has been shown to carry thyroxin activity. A study of secretion rate of different species of poultry indicates a relationship between thyroxin secretion rate and growth rate. Some research work indicates that feeding of iodinated casein to replace and augment the natural secretion rate of the thyroid gland should result in faster growth and better feathering. There is some evidence that response to iodinated casein is better in rations with B_{12} or fish meal. This experiment was arranged to study the effect of feeding a continuous level of 0.04 percent thyroprotein to broiler type chickens in batteries up to 8 weeks of age. Two types of rations were used, one with soybean oil meal as a source of protein and the other with soybean oil meal plus 5 percent of fish meal.

Table 6. Effect of Iodinated Casein on Growth Rate and Feed Efficiency.

Ration Number	Protein Concentrates			Iodinated Casein Grams	Protein Level Percent	Average Weight		Feed Per Pound Gain
	Soybean Oil Meal	Meat Scrap	Fish Meal			4 Wks. Lbs.	8 Wks. Lbs.	
4805	19.0	2.5	5.0	-	20.9	.86	2.30	2.57
4806	19.0	2.5	5.0	18	20.9	.85	2.09	2.81
4807	26.0	-	-	-	19.5	.78	2.09	2.81
4808	26.0	-	-	18	19.5	.70	1.80	3.21

Addition of iodinated casein at a level of 18 grams per 100 pounds (0.04 percent) to rations containing 5 percent fish meal did not affect growth rate at 4 weeks of age. It decreased growth rate, as measured by body weight, between 4 and 8 weeks of age. The effect with all soybean meal protein ration 4808 was more marked and expressed at an earlier age. In this test the use of iodinated casein decreased weight at 8 weeks about 15 percent. Externally, the birds on iodinated casein appeared as large or larger and were well feathered but failed to carry sufficient flesh and fat to attain good weights.

Ground wheat in ration 4809 appeared to be equal if not slightly superior in growth rate and feed efficiency, compared to similar rations using mill

Table 7. Effect of Substitution of Ground Wheat for Wheat Shorts and Wheat Bran.

Ration Number	Wheat Shorts	Wheat Bran	Ground Wheat	Protein Level	Average Weight 4 Weeks lbs.	Average Weight 8 Weeks lbs.	Feed Efficiency
4803	15	5	--	20.2	.77	2.10	2.79
4809	--	-	20	19.4	.77	2.14	2.69

by-products of wheat. Higher energy value of whole wheat, compared to shorts and bran, could be a factor. When prices permit, ground wheat can be substituted for shorts and bran at these levels.

Table 8. Floor Tests on Rations 4801, 4803, 4804 - Fall 1948. 150 Broiler Type Chicks per Ration.

Ration Number	Protein Concentrates: Soybean Oil Meal	Meat Scraps	Dried Milk	Alfalfa Meal Percent	Protein Level Percent	Average Weight: 4 Week Pounds	10 Week Pounds	Feed Efficiency
4801	15.0	7.0	-	10.0	19.5	.67	2.63	3.83
4803	19.0	7.5	-	-	20.2	.83	2.89	3.27
4804	14.5	7.5	5.0	-	20.0	.77	2.83	3.37

The floor brooding ration trials bear out findings of the battery tests reported in Table 3. Ration 4801 with 10 percent of alfalfa meal resulted in 20 percent lower weight at 4 weeks and 10 percent lower weight at 10 weeks than a similar ration (4803) without alfalfa. Again the addition of milk to the soybean-meat scrap failed to improve growth rate. It will be noticed that as the birds became older there was less difference in growth rate due to the rations used.

Series C, 1949—Comparison of Crystalline Riboflavin to Dried Fermentation Solubles for Riboflavin Supplementation in Chick Rations

The question often arises as to the comparative values of these two products in chick rations. Since dried fermentation solubles carry a number of other "B" vitamins and are a natural fermentation product, they might be expected to be a superior supplement. Table 9 compares 4 sets of rations with different types of protein supplement and variable sources of riboflavin These tests compare rations 4901 to 4902, 4903 to 4904, 4905 to 4906, and 4908 to 4909. Four replications of 25 birds each were used in each test.

It is quite evident from these tests that no advantage could be claimed for dried fermentation solubles, at the level fed in the four types of rations, as a source of riboflavin and extra "B" vitamins. Apparently both crystalline riboflavin and dried fermentation solubles were satisfactory sources of riboflavin. No explanation is offered for the high degree of variation between the two fish meal rations (4905 and 4906).

Table 9, Series C--Dried Fermentation Solubles and A. P. F. in Chick Rations, 1949.

	4901	4902	4903	4904	4905	4906	4907	4908	4909
	Percent or pounds per 100# except where indicated								
Yellow Corn Meal	52.8	52.8	52.8	52.8	52.6	52.6	50.5	50.5	50.5
Wheat Shorts	15.0	15.0	15.0	15.0	15.0	15.0	13.0	13.0	13.0
Wheat Bran	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Soybean Oil Meal	18.0	18.0	18.0	18.0	18.0	18.0	27.0	27.0	27.0
Meat and Bone Scrap	7.5	7.5	7.5	7.5	5.0	5.0	-	-	-
Fish Meal	-	-	-	-	2.5	2.5	-	-	-
Bone Meal	-	-	-	-	-	-	2.0	2.0	2.0
Ground Limestone	1.0	1.0	1.0	1.0	1.2	1.2	1.5	1.5	1.5
Feed Oil (400 D)	.25	.25	.25	.25	.25	.25	.25	.25	.25
Salt	.05	.05	.05	.05	.05	.05	.75	.75	.75
Mn SO_4	.02	.02	.02	.02	.02	.02	.02	.02	.02
Riboflavin mg.	100.	-	100.	-	100.	-	100.	-	100.
"B" Vit. Supp.*1 gm.	-	12.5	-	12.5	-	12.5	-	15.	-
A. P. F. *2 gm.	-	-	70.	70.	-	-	-	115.	115.
Calculated Analysis									
Protein %	19.7	19.7	19.7	19.7	19.9	19.9	19.6	19.6	19.6
Riboflavin mg.	199.	199.	199.	199.	199.	199.	197.	217.	197.
Results *3									
Ave. Wt. 4 wk. lbs.	.70	.68	.70	.70	.69	.65	.64	.71	.72
Ave. Wt. 8 wk. lbs.	1.98	1.94	2.03	2.03	2.05	1.92	1.90	2.09	2.09

*1. "B" vitamin supplement was dried fermentation solubles containing 8.0 mg. riboflavin, 0.2 mg. pantothenic acid, .2 mg. niacin, 9.4 mg. choline, .002 mg. folic acid per gram.

*2. Animal protein supplement contained B_{12} and antibiotic properites.

*3. Battery tests average of 4 tests - 25 straight run chicks per test, fall 1949. Heavy breed W. R., N. H.

Table 10. Riboflavin Supplementation - From Table 9, Series C.

	Type of Protein and A. P. F. Supplementation				
Variables	Soybean Meal and Meat Scrap	Soybean Meal Meat Scrap & A. P. F. 0.15%	Soybean Meal Meat Scrap Fish Meal	Soybean Meal and A. P. F. 0.25%	All Ration Average
Crystalline Riboflavin 8 Week Wt.	1.98	2.03	2.05	2.09	2.037
Dried Fermentation Solubles 8 Week Wt.	1.94	2.03	1.92	2.09	1.995
Deviation	-2.0%	0.0	-7.8%	0.0	-2.1%

Animal Protein Factor Supplementation, 1949

Interest in an unknown vitamin or nutrient found in liver, fish meal, cow manure, and, to a lesser extent, in meat scrap and milk was intensified when it was found that a similar growth stimulus was provided by including crude by-products from the production of penicillin or other antibiotics. Early work attributed the value of these products to their B_{12} activity. It was not learned until later that the growth stimulus was due to both B_{12} and antibiotic properties. These early products were called A. P. F. supple-

ments. They were fed in crude forms and were not assayed for B_{12} or antibiotic activity.

Table 11. Supplementation With A. P. F. (Animal Protein Factor) 1949. From Table 9, Series C.

Variable	Type of Protein Supplements: Soybean Oil Meal	Soybean Meal + Meat Scrap	Soybean + Fish Meal + Meat Scrap
No Animal Protein Factor 8 Weeks Weight	1.90	1.96	1.99
Animal Protein Factor Added 8 Weeks Weight	2.09(0.25%)*	2.03(0.15%)*	No test
+ Deviation Due to A. P. F.	+10.0%	+3.6%	

*Indicates level of A. P. F. Supplementation.

The experiment in Table 11 illustrates stimulation due to these early crude "A. P. F." suplements. The all soybean meal protein ration 4907 gave a growth rate of 1.90 alone, 1.96 with meat scrap and 1.99 with meat scraps and fish meal indicating slight growth response to factors in the animal protein. Addition of 0.25 percent of A. P. F. to the all vegetable protein ration caused an increase in growth from 1.90 to 2.09 or 10 percent increase. When 0.15 percent A. P. F. was added to a ration containing soybean oil meal and meat scrap there was a slight growth response of 3.6 percent. It was not possible from this experiment to determine the level of supplementation necessary for maximum growth or how much of the increased growth response could be attributed to B_{12} and antibioitic activity, respectively.

Fish meal used in this experiment was of uncertain quality and was used at only 2.5 percent level, which probably was insufficient to supply all of the necessary B_{12}. These conditions did not allow a perfect comparison. But they seemed to indicate that B_{12} was responsible for about half of the increased growth rate because the ration with fish meal and meat scrap was exactly intermediate between the soybean meal ration without A. P. F. and the all soybean meal ration plus A. P. F. at 0.25 percent level.

Effect of B_{12} and Antibiotics on Growth Rate and Feed Efficiency of Chicks

Recognization that most "A. P. F. " and antibiotic feed supplements contained both B_{12} and antibiotic activity led to the requirement that such products be identified. The term "A. P. F." was dropped and assays indicated the B_{12} activity in milligrams and the antibiotic activity in grams per pound of supplement. Suitable sources of synthetic B_{12} and antibiotic were then available to design experiments that would separate the growth response due to each of the two factors.

Rations 5002 and 5010, which were all vegetable protein rations plus B_{12} and antibiotic, showed 16.8 to 18.6 percent increase in growth rate over

Table 12, Series D, 1950. Effect of Synthetic B_{12} and Antibiotic on Growth Rate and Feed Efficiency.

	5001	5002	5003	5004	5005	5006	5007	5008	5009	5010
	Percent or pounds per 100# except as indicated									
Yellow Corn Meal	51.0	51.0	51.0	50.0	52.0	51.0	50.0	50.0	50.0	60.5
Wheat Shorts	13.0	13.0	13.0	13.0	15.0	15.0	15.0	15.0	15.0	-
Wheat Bran	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	-
Soybean Oil Meal	27.0	27.0	27.0	27.0	20.0	24.0	24.0	24.0	24.0	35.0
Fish Meal	-	-	-	-	5.0	2.5	2.5	2.5	2.5	-
Dried Whey	-	-	-	1.0	-	1.0	-	-	-	-
Bone Meal	1.5	1.5	1.5	1.5	1.0	1.0	1.25	1.25	1.25	2.00
Limestone	1.5	1.5	1.5	1.5	1.5	1.5	1.50	1.50	1.50	1.50
Salt	.75	.75	.75	.75	.50	.50	.50	.50	.50	1.00
Feed Oil (400 D)	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25
Mn SO_4	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
Riboflavin mg.	150.	150.	150.	150.	150.	150.	150.	150.	150.	150.
B_{12} mg.	0	.5	.5	.5	-	-	-	.25	.25	.5
Antibiotic gm. *1	0	.5	-	-	-	-	-	.25	-	.5
Calculated Analysis										
Protein %	19.5	19.5	19.5	19.5	20.1	20.1	19.9	19.9	19.9	20.7
Calcium %	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3
Phosphorus %	.72	.72	.72	.72	.77	.77	.76	.76	.76	.70
Results *2										
8 Week Wts. lbs.	1.90	2.25	2.02	2.09	2.09	2.05	2.03	2.10	2.01	2.21
% Deviations	0.0	+18.6	+6.3	+10.0	+10.0	+8.0	+7.2	+11.0	+6.0	+16.8
Feed Eff. 8 Wk.	3.04	2.75	2.94	2.98	2.77	2.80	3.02	2.85	2.87	2.70
% Deviations	0.0	+10.5	+3.4	+2.7	+9.7	+9.0	+0.7	+6.7	+6.0	+12.6

*1. Aureomycin used as antibiotic.
*2. Summary two tests - 2 samples per test of 25 straight run University of Missouri Dual Purpose New Hampshire Chicks.

Table 13. Effect of B_{12} and Antibiotic on Growth Rate.
(Taken from Table 12, Series D.)

	Protein Source		Synthetic		Ave. Wt.		% Deviation
Ration	Soybean Oil Meal	Fish Meal	B_{12}	Anti-biotic	4 Wk. Lbs.	8 Wk. Lbs.	from Basal Ration 5001
5001	27.0	-	-	-	.67	1.90	0.0
5002	27.0	-	.50mg.	.50gm.	.79	2.25	+18.6
5003	27.0	-	.50mg.	-	.69	2.02	+6.3
5005	20.0	5.0	-	-	.74	2.09	+10.0
5007	24.0	2.5	-	-	.70	2.03	+7.0
5008	24.0	2.5	.25mg.	.25gm.	.81	2.10	+11.0
5009	24.0	2.5	.25mg.	-	.72	2.01	+6.0
5010	35.0	--	.50mg.	.50gm.	.80	2.21	+16.8

the basal 5001. They also showed an improved feed efficiency of 10 to 12 percent. Rations 5003, 5007, 5009, using fish meal and B_{12} without antibiotic, showed an increase in growth rate over the basal 5001 of from 6 to 7 percent. This was attributed primarily to B_{12}. Ration 5008, where only .25 milligram of synthetic B_{12} gave an intermediate response of 11 percent over the basal, indicated insufficient antibiotic for maximum growth. Ration 5005 with 5 percent fish meal and no antibiotic gave a growth response

of +10 percent over the basal. This is apparently more response than could be expected from the B_{12} in the fish meal and indicates that fish meal may carry some other unidentified growth factor. In summary it appears from experiments with this type of ration that B_{12} alone can improve growth rate. about 6 to 7 percent and that aureomycin at a level of .5 gram per 100 pounds of feed can make a further improvement of 10 to 11 percent in growth rate up to 8 weeks of age. Rations 5004 and 5006 with 1 percent of whey gave +2.7 percent and +0.8 percent increase over their respective controls Rations 5003 and 5007. This difference is too small to be significant but fairly consistent between lots and replications.

Floor Brooding Feed Tests with Rations Containing B_{12} and Antibiotics

Following the battery tests in Series D, three rations were selected for testing under farm brooding conditions. Each of the three rations were tested on both clean litter and old built-up litter in 10 ft. by 12 ft. pens with 100 straight run dual purpose type New Hampshires per lot.

Table 14. Clean Compared to/Built-up Litter

Ration Number	Type Litter	Type Protein Soybean Meal	Type Protein Fish Meal	Synthetic Supplements B_{12}	Synthetic Supplements Antibiotic	Ave. Wt. 4 Wk. Lbs.	Ave. Wt. 8 Wk. Lbs.	4 Wk. + Deviations
5001	Clean	27.0	-	-	-	.72	1.32	0.0
5001	Built-up	27.0	-	-	-	.81	1.66	+13.1
5002	Clean	27.0	-	.5mg.	.5gm.	.84	1.74	+17.1
5002	Built-up	27.0	-	.5mg.	.5gm.	.84	1.74	+17.1
5005	Clean	20.0	5.0	-	-	.85	1.88	+18.4
5005	Built-up	20.0	5.0	-	-	.86	1.81	+19.6

This data would indicate built-up litter improved growth rate where the ration was deficient in B_{12} and animal proteins. Ration 5001 on built-up litter was 13.1 percent faster growing than 5001 on clean litter. No additional value could be attributed to built-up-litter when rations contained B_{12} plus antibiotics or 5 percent fish meal. Assuming the built-up litter furnished sufficient B_{12}, then the added response to antibiotic was only about 4 percent.

There was very little difference in growth rate up to 4 weeks of age with chicks on all vegetable protein ration 5002 with B12 and antibiotic, compared to chicks on similar ration 5005 with 5 percent fish meal added. At 8 weeks there was considerable difference (about 6 percent) favoring the fish meal ration. Part of this difference was probably due to growth promoting qualities of fish meal. Some confusion of these results may have been due to a severe outbreak of coccidiosis between 6 and 7 weeks of age that was much more prevalent in lots on Rations 5001 and 5002 and caused very little trouble on Ration 5005

Series E, Effect of B_{12} and Antibiotic on Chick Growth and Feed Efficiency

In Table 15 a series of rations are shown, designed to compare rations made up of natural feed ingredients with rations containing synthetic sources of B_{12} and antibiotics. An effort was made to separate the effect of B_{12} and antibiotic but this attempt was not fully successful as the crude B_{12} and antibiotic supplements used carried sufficient supply of both components to confuse the data.

Table 15, Series E--Effect of Synthetic B_{12} and Antibiotic on Chick Growth and Feed Efficiency - Spring, 1951.

Ingredient Ration No.	5101	5102	5103	5104	5105	5106	5107	5108
Yellow Corn Meal	52.5	51.0	51.0	51.0	51.0	52.0	52.0	60.5
Wheat Shorts	10.0	13.0	13.0	13.0	13.0	15.0	15.0	----
Wheat Bran	3.75	5.0	5.0	5.0	5.0	5.0	5.0	----
Soybean Oil Meal	22.5	27.0	27.0	27.0	27.0	20.0	20.0	35.0
Alfalfa Meal	1.5	----	----	----	----	----	----	----
Fish Meal	3.5	----	----	----	----	5.0	5.0	----
Dried Milk	3.0	----	----	----	----	----	----	----
Bone Meal	1.0	1.5	1.5	1.5	1.5	1.0	1.0	2.0
Limestone	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Salt	0.5	0.5	0.8	0.8	0.8	0.5	0.5	1.0
Feed Oil (400 D)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mn SO_4	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
Riboflavin mg.	----	150.0	150.0	150.0	150.0	150.0	150.0	150.0
B_{12} mg. *1	----	----	0.5	0.5	----	----	0.5	0.5
Antibiotic gm. *2	----	----	----	0.5	0.5	----	0.5	0.5
Results*3								
Test 1-4 wk. wt. lbs	.84	.74	.85	.85	.86	.86	.89	.88
Test 2-4 wk. wt. lbs	.70	.57	.70	.70	.73	.67	.78	.75
Average 4 wk. wt. lbs	.77	.66	.77	.78	.80	.77	.83	.82
Dev. from R. 5102	+16.8%	0.0	+17.4%	+18.3%	+20.7%	+16.1%	+26.4%	+24.4%
Test 1-8 wk. wt.	2.21	2.02	2.28	2.28	2.28	2.32	2.43	2.35
Test 2-8 wk. wt.	2.04	1.75	2.04	2.13	2.08	2.00	2.20	2.16
Average 8 wk. wt.	2.12	1.88	2.16	2.21	2.16	2.16	2.36	2.25
Dev. from R. 5102	+12.7%	0.0	+14.8%	+17.5%	+14.8%	+14.8%	+22.9%	+19.6%
Test 1-Feed Eff. 8 wk.	2.92	3.12	2.82	3.00	2.87	2.82	2.81	2.74
Test 2-Feed Eff. 8 wk.	2.62	2.91	2.74	2.74	2.65	2.68	2.56	2.57
Average Feed Eff. 8 wk.	2.77	3.01	2.78	2.83	2.79	2.75	2.68	2.65
Dev. from R. 5102	+8.0	0.0	+8.0	+6.0	+7.4	+8.7	+11.0	+12.0

*1. B_{12} supplement carried some antibiotic activity.
*2. Antibiotic supplement carried some B_{12} activity.
Note: All rations calculated 20.0% protein $\pm$ 0.5%
*3. Results - Two tests
Test 1-Straight run dual purpose New Hampshires
Test 2-Leghorn x Heavy Breed cockerels.

After completion of these trials biological assays of the products used showed the B_{12} supplement carried about ¼ of the recommended antibiotic requirement. Therefore, although the growth promotion effect of both B_{12} and antibiotic at 8 weeks was 17 to 19 percent over the basal, either supplement alone gave from 14 to 15 percent increase. The 4-week data a-

grees in general with the 8-week data, except the general magnitude of effect was about 4 percent greater at 4 weeks than at 8 weeks. This indicates that as the birds grow older B_{12} and antibiotic have less growth promoting properties, that the bird synthesizes its own B_{12}, or that it reaches a more nearly optimum level of intestinal florea.

Table 16. B_{12} and Antibiotic Supplements in Chick Rations. (From Table 15, Series E)

	Protein and other Supplements								
Ration Number	Soybean Oil Meal	Fish Meal	Dried Milk	B_{12} mg.	Anti-biotic gms.	Ave. Wt. 8 wk. lbs.	Dev. % from R5102	Feed Eff. 8 wk.	Dev. % from R5102
5101	22.5	3.5	3.0	-	-	2.12	+12.7	2.77	+8.0
5102	27.0	-	-	-	-	1.88	0.0	3.01	0.0
5103	27.0	-	-	.5mg.	-	2.16	+14.8	2.78	+8.0
5104	27.0	-	-	.5mg.	.5gm.	2.21	+17.5	2.83	+6.0
5105	27.0	-	-	-	.5gm.	2.16	+14.8	2.79	+7.4
5106	20.0	5.0	-	-	-	2.16	+14.8	2.75	+8.7
5107	20.0	5.0	-	.5mg.	.5gm.	2.31	+22.9	2.68	+11.0

Using the all soybean meal protein ration 5102 as a basal ration we see that fish meal and milk, at the levels in 5101, gave a 12.7 percent increase in growth rate and 8 percent better feed efficiency. A 5 percent fish meal ration 5106 was even better with 14.8 percent faster growth and 8.7 percent better feed efficiency. Ration 5104, which is basal plus B_{12} and antibiotic, gave 17.5 percent increase in growth and 6 percent improved feed efficiency. As previously mentioned, both ration 5103 and 5105, with B_{12} and antibiotic supplement, respectively, gave a 14.8 percent increase in growth. Since this was not additive in ration 5104 it indicated contamination of the B_{12} and antibiotic supplements, which later assays proved correct. Ration 5107, with 5 percent of fish meal and B_{12} and antibiotic, gave the largest stimulation with 22.9 percent increase.

Since fish meal probably carries sufficient B_{12}, the difference in rations 5106 and 5107 could be ascribed to the antibiotic. This difference is about 8 percent. Comparing 5104 and 5107, there is a difference of 5.4 percent which must be credited to a factor or factors in fish meal. This series would indicate that the B_{12} improved growth rate about 9 percent, the antibiotic an additional 8 percent and the fish meal an additional 5 percent. Improved feed efficiency was in about the same order but at about half the magnitude of the growth rate. Since all birds were not grown to the same weight, the feed efficiency does not afford exact comparison.

Table 17. Effect of Energy Level on Growth Rate and Feed Efficiency. (From Table 15, Series E)

		Feed Variables		Therms per		
Ration Number	Wheat Shorts	Wheat Bran	Soybean Meal	100 lbs. Feed	Ave. Wt. 8 Week	Feed Eff.
5104	13.0	5.0	27.0	73.6	2.21	2.83
5108	----	---	35.0	75.9	2.25	2.65
% Deviation from Ration		5104		+3.1	+1.8	+6.4

A comparison of rations 5104 and 5108, which differ primarily due to the bran and shorts in 5104, indicates the major difference is due to the energy level of these two rations. Ration 5108, which is a corn-soybean meal ration, calculates 2.3 Therms or 3.1 percent higher in energy than a similar ration with some wheat shorts and bran. This difference caused a 1.8 percent faster gain on 6.4 percent less feed.

Table 18, Series F--Summer and Fall, 1951 - Comparison of Departmental and Commercial Broiler Rations.

Ration Number	5111	5112	5113	5114	5115	5116	5117	5118	5119	5120*1
	Percent or pounds per 100#, except as Indicated									
Yellow Corn Meal	52.0	52.0	60.5	60.5	51.0	51.0	62.0	63.0	60.5	
Wheat Shorts	15.0	15.0	----	----	13.0	13.0	----	----	----	
Wheat Bran	3.5	3.5	----	----	3.5	3.5	----	----	----	
Soybean Oil Meal	19.0	19.0	35.0	35.0	27.0	27.0	28.0	26.0	35.0	
Alfalfa Meal	1.5	1.5	----	----	1.5	1.5	1.5	1.5	----	
Fish Meal	----	----	----	----	----	----	5.0	----	----	
Meat Scrap	7.5	7.5	----	----	----	----	----	7.5	----	
Bone Meal	----	----	2.0	2.0	1.7	1.7	1.0	----	2.0	
Ground Limestone	1.0	1.0	1.5	1.5	1.5	1.5	1.5	1.0	1.5	
Salt	0.5	0.5	1.0	1.0	0.8	0.8	0.8	0.8	1.0	
Feed Oil (400 D)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	
Mn SO_4	0.02	0.02	0.03	0.03	.02	.02	.02	.02	.03	
Riboflavin mgs.	150.0	----	150.0	----	150.0	----	----	----	----	
"B" Vitamin Mix	----	*2	----	*2	----	*2	*2	*2	*2	
B_{12} mg.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.6	
Aureomycin gm.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	----	
Penicillin gm.									0.1	
Results*3										
Test 1 - 4 wk. wt. (lbs.)	.87	.90	.87	.87	.87	.82	.89	.94	.87	.84
Test 2 - 4 wk. wt. (lbs.)	.82	.85	.80	.80	.81	.81	.78	.84	.82	.73
Test 3 - 4 wk. wt. (lbs.)	.79	.76	.74	.74	.72	.73	.76	.80	.81	.75
Average 3 Tests (lbs.)	.83	.84	.80	.80	.80	.79	.81	.86	.84	.78
Dev. from (R5120)%	+6.4	+7.4	+3.1	+3.1	+3.0	+1.1	+4.0	+10.5	+7.4	0.0
Ave. Feed Eff. 4 wk.	2.17	2.05	2.09	2.05	2.25	2.22	2.22	2.14	2.04	2.42
Dev. from (R5120)%	+10.3	+15.3	+13.6	+15.3	+7.0	+8.3	+8.3	+11.6	+15.7	0.0
Test 1 - 8 wk. wt. (lbs.)	2.21	2.31	2.32	2.33	2.29	2.23	2.29	2.38	2.20	2.26
Test 2 - 8 wk. wt. (lbs.)	2.32	2.32	2.30	2.31	2.38	2.32	2.35	2.34	2.35	2.19
Test 3 - 8 wk. wt. (lbs.)	2.09	2.15	2.12	2.18	2.07	2.17	2.25	2.30	2.18	2.22
Ave. 3 Tests 8 wk. (lbs.)	2.21	2.26	2.25	2.27	2.25	2.24	2.30	2.34	2.24	2.22
Dev. from (R 5120)%	-0.5	+1.8	+1.4	+2.3	+1.4	+0.9	+3.6	+5.4	+0.9	0.0
Ave. Feed Eff. 8 wk.	2.75	2.72	2.68	2.72	2.88	2.73	2.66	2.59	2.65	2.93
Dev. from (R 5120)%	+6.2	+7.2	+8.5	+7.2	+1.7	+6.8	+9.2	+11.6	+9.6	0.0

*1. Ration 5120 was a standard commercial Broiler Ration.

*2. "B" Vitamin Mix supplied 150 mg. Riboflavin, 290 mg. Calcium Pantothenate, 435 mg. Niacin, 1450. mg. Choline Chloride per 100 lb. feed.

*3. Results of three tests - 2 replications of 25 birds on each ration each test. May, Sept., Oct. 1951. Broiler and semibroiler straight run chicks.

Series F, Comparison of Departmental and Commercial Broiler Rations, From Table 18

It appeared desirable to test a number of the Poultry Department rations against a good commercial broiler mash before releasing these formulae. Three separate battery tests were run with 2 replications of 25 straight run chicks on each ration each test. Nine Departmental rations were used, 5111 through 5119, and one commercial mash designated as 5120. In growth rate at 4 weeks of age, all Departmental rations were superior with a range of from +1.1 percent to +10.5 percent with an average of +5.1 percent. At 8 weeks of age the difference in growth was considerably less, with 8 of the 9 being slightly superior to the commercial. The range was -0.5 percent to +5.4 percent, with an average of +1.9 percent at 8 weeks. Feed efficiency differences were more marked with the Departmental rations ranging from +1.7 percent to +11.6 percent or an average improved efficiency over the commercial ration of +7.55 percent.

This series of rations also allowed a comparison of crystalline riboflavin in rations 5111, 5113, and 5115 to the same basic rations containing a "B" vitamin supplement (rations 5112, 5114 and 5116) as shown in Table 18.

Table 19. Extra "B" Vitamin Supplementation (From Table 18)

Variable	Average effect on 3 types rations	
	Growth rate 8 wks.	Feed eff. 8 wks.
Crystalline Riboflavin	2.237	2.77
"B" Vitamin Supplement	2.257	2.72
+ Dev. favoring "B" Supplement	+0.9%	+1.8%

This difference, though exceedingly small was significant due to the consistency between replications. If a feed value of 5 cents per pound is credited, the increased cost of the "B" vitamin supplement is about 48 cents per ton above the cost of synthetic riboflavin. Per 1,000 broilers marketed, using 5 tons of feed, the increased cost would be $2.40. The saving in feed at 1.8 percent would be 180 pounds. At 5 cents per pound this would be worth $9.00 or a net saving of $6.60 per 1,000 broilers produced, favoring the "B" vitamin supplementation, even though no additional value was attributed the slightly faster growth rate (+0.9 percent from extra "B" vitamin).

Table 20. Energy Level Effect of Rations With Wheat Shorts and Bran 5112 and 5116 Compared to Similar Rations 5514 and 5118 With no Wheat By-Products.

(From Table 18)

Variable	Average of 2 types rations		
	Energy level Therms/100#	8 week Weights	8 week Feed Eff.
Wheat by-product 17.5%	73.8	2.250	2.725
No Wheat by-products	75.8	2.305	2.655
+ Deviations to higher energy	+3.0%	+2.4%	+2.6%

At 8 weeks of age the percent increase in feed efficiency and growth rate were in almost direct proportion to percent increase of energy level of rations. This is similar to results in Series E, Table 17. However, the increased number of replications apparently cancelled out some of the error.

Effect of Type of Antibiotic on Growth Rate

A comparison of Ration 5113 with 10 grams of aureomycin per ton to Ration 5119 with 2 grams of procaine penicillin per ton showed growth rates of 2.25 and 2.24, respectively. Feed efficiency was 2.68 to 2.65. There was no difference in the effectiveness of one antibiotic over the other at levels indicated.

Effect of Protein Level After 8 Weeks of Age On Growth Rate and Feed Efficiency

Following the battery tests at 8 weeks of age, the 500 birds were divided into 2 lots and placed on 18 percent and 16 percent protein levels for an average period of 10 feeding days. Results are given below:

Table 21. Effect of Protein Level After 8 Weeks of Age.

	Protein Level	Initial Wt.	Gain	Feed Efficiency
Lot 1	18%	2.19	.569	3.81
Lot 2	16%	2.21	.555	3.86

Both 16 and 18 percent levels gave satisfactory growth rate and feed efficiency for the average 10 day period. Males were sold after 7 days and females after 13 days. No significant advantage is shown for the 18 percent protein level at this age and weight. Substitution of lower protein level by the addition of more corn meal is apparently an economical practice, if considerable difference exists in price of protein supplements.

Effect of Type of Protein Supplementation

If the "exception proves the rule" Series F results with fish meal and meat scrap may have some value. Animal proteins were difficult to obtain through regular trade channels at this time at Columbia, Mo. The fish meal finally located was of unknown origin and analysis. The meat scrap came from a small packing house in Kansas.

Table 22. Effect of Source of Meat Scrap and Fish Meal on Results. (From Table 18, Series F.)

Ration	Type Protein			8 wk. data			
	Soybean Meal	Fish Meal	Meat Scrap	Weight Pounds	% Deviation	Feed Eff.	% Deviation
5114	35.0	---	---	2.27	0.0%	2.72	0.0%
5117	28.0	5.0	---	2.30	+1.3	2.66	+2.2%
5118	26.0	---	7.5	2.34	+3.1%	2.59	+5.0%

Since the rations were supplemented with sufficient synthetic B_{12}, the improvement in growth rate on ration 5118, containing 7.5 percent meat scrap, must have been due to some factor in the meat scrap. Sufficient replications made the results significant. The only explanation offered is that this small packing house was apparently including glandular material or other products not present in most commercial meat scrap. Analysis of the fish meal showed it contained only 50 percent protein and was of low quality which also might explain why it failed to give maximum response.

Series G, Floor Brooding Tests

Following the battery tests on Series G; Rations 5113, 5117, 5118 and the Commercial Ration 5120 were selected to test under floor brooding conditions. Two replications of 100 crossbred broiler chicks were used on clean and built up litter. For complete outline of rations see Series F, Table 18.

Rations Selected for Floor Tests:

Ration 5113—All soybean meal $+B_2$, B_{12} and antibiotic.
Ration 5117—Soybean-fish meal $+B_2$, B_{12} and antibiotic.
Ration 5118—Soybean-meat scrap $+B_2$, B_{12} and antibiotic.
Ration 5120—A standard Commercial Broiler Ration.

Table 23. Effect of Type of Litter and Ration on Growth Rate and Feed Costs

Ration Number	Type Litter	4 wk. data Wt. Lbs.	60 day data		Feed Cost Per Lb. Gain
			Wt. Lbs.	Feed Eff.	
5113	Clean	.839	2.57	2.80	$.1193
5113	Built-up	.848	2.65	2.84	
5117	Clean	.863	2.54	2.78	$.1269
5117	Built-up	.846	2.48	2.86	
5118	Clean	.912	2.55	2.86	$.1250
5118	Built-up	.889	2.55	2.82	
5120	Clean	.729	2.35	3.04	$.1500
5120	Built-up	.791	2.48	2.85	

There was no significant difference in growth rate from the three Departmental Rations 5113, 5117 or 5118. All of the Departmental Rations were equal or slightly superior to the Commercial Ration No. 5120 in both growth rate and feed efficiency. Feed cost per pound of gain favored the all soybean meal ration 5113. The Commercial Ration was considerably higher

Table 24, Series G--Effect of Supplementation of Fish Meal, Meat Scraps, Shorts, Extra "B" Vitamins and Type of Soybean Meal in Rations with Sufficient B_{12} and Antibiotic.

	5201	5202	5203	5204	5205	5206	5207	5208	5209	5210*3
Yellow Corn Meal	58.75	59.25	59.25	59.25	51.25	62.50	62.50	54.50	63.50	59.25
Wheat Shorts	-----	-----	-----	-----	10.0	-----	-----	10.0	-----	-----
Soybean Meal *1	35.0	35.0	35.0*1	35.0	33.0	28.0	28.0	26.0	26.0	35.0
Alfalfa Meal	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Fish Meal	-----	-----	-----	-----	-----	5.0	5.0	5.0	-----	-----
Meat Scrap	-----	-----	-----	-----	-----	-----	-----	-----	7.5	-----
Bone Meal	2.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0	-----	2.0
Limestone	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.0	1.5
Salt	1.0	.5	.5	.5	.5	.3	.3	.3	.25	.5
Mn SO_4 gm	12	12	12	12	10	9	9	9	9	12
Riboflavin mg.	150	150	150	-----	150	150	-----	150	150	150
"B" Vitamin Mix *2				*2			*2			
B_{12} mg.	.45	.45	.45	.45	.45	.45	.45	.45	.45	.45
Antibiotic gm.	.45	.45	.45	.45	.45	.45	.45	.45	.45	.45*3
Feed Oil (400 D)	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25
Results*4										
Test 1 - 4 wk. wt. lbs.	.83	.88	.90	.86	.84	.89	.89	.87	.80	.83
Test 2 - 4 wk. wt. lbs.	.91	.87	.88	.90	.90	.91	.99	.92	.82	.89
Average two tests.	.87	.87	.89	.88	.87	.90	.94	.89	.81	.86
Ave. 4 wk. Feed Eff.	2.21	2.27	2.10	2.13	2.06	2.13	1.80	2.12	2.34	2.05
8 wk. data										
Test 1 - 8 wk. wt. lbs.	2.22	2.28	2.30	2.29	2.19	2.30	2.32	2.28	2.05	2.20
Test 2— 8 wk. wt. lbs.	2.52	2.40	2.49	2.49	2.37	2.58	2.67	2.46	2.31	2.49
Ave. 2 Tests wt.	2.37	2.34	2.39	2.39	2.28	2.44	2.49	2.37	2.18	2.34
Dev. from 5201	0.0	-1.3%	+0.8%	+0.8%	-3.8%	+3.0%	+5.1%	0.0	-8.0%	-1.3%
Ave. Feed Eff. 8 wk.	2.77	2.70	2.58	2.57	2.68	2.54	2.36	2.61	2.78	2.60
Dev. from 5201	0.0	+2.2%	+6.8%	+7.2%	+3.2%	+8.3%	+14.8%	+5.8%	-0.4%	+6.2%

*1. Ration No 5203 used expeller soybean meal. All others solvent process.
*2. "B" Vitamin Mix supplied 150 mg. B_2, 300 mg. pantothenic acid, 150 mg. niacin, 750 mg. choline and 4 mg. folic acid per 100# of ration.
*3. Same as Ration 5202 except rimocidin (yeast and mold antibiotic) was added to aureomycin.
*4. Two tests in batteries, Spring and Fall 1952. Two replications of 25 straight run chicks on each ration each test.
Test 1. Crossbred White Leghorn x Heavy Breed males.
Test 2. Broiler Strain Straight Run New Hampshires.

due to decreased feed efficiency and greater cost per 100 pounds of feed. Ration 5113 cost $4.23 per 100 pounds, compared to the commercial price of $5.10 for Ration 5120.

Combined averages on growth rate showed 2.53 for built-up litter, compared to 2.50 on clean. Feed efficiency also slightly favored the old litter with 2.84 as compared to 2.87. These differences were not significant. In this series the fish meal failed to give any boost to the ration. It was not identified as to source or analysis. There was no difference in mortality rate on the two types of litter.

Effect of Salt Level

Birds on a 1 percent salt level (Ration 5201) gave a 1.3 percent faster growth and 1.1 percent better feed efficiency than birds on 0.5 percent salt with similar ration 5202. This difference was not significant and could have been accounted for by the water intake of the birds. There was a significant difference in percent of moisture in the droppings as the birds on 0.5 percent salt produced droppings that were 7 to 10 percent lower in moisture than birds on a 1 percent level. From a management viewpoint this is important.

Effect of Method of Soybean Oil Meal Preparation

Ration 5203 with expeller process soybean meal gave 2 percent better growth and 2.2 percent better feed efficiency than ration 5202 with solvent process. This is well within experimental error and no difference in values is attributed to the meals.

Effect of "B" Vitamin Mix to Crystalline Riboflavin

Two comparisons were possible; first with all vegetable protein in rations 5202 and 5204 and second with soybean + fish meal rations 5206 and 5207.

Table 25. Effect of Extra "B" Vitamins

Variable	Average of two types rations	
	8 wk. weight	8 wk. feed eff.
Crystalline Riboflavin	2.39	2.62
"B" Vitamin Mix	2.44	2.47
+ Deviations	+2.1%	+6.1%

Results in Table 25 are in agreement with results obtained in Series F and of greater magnitude. A 6 percent better feed efficiency would amount to a saving of about $25.00 per 1,000 broilers above additional cost of these vitamins. It was not determined whether the feed difference was due to difference in feed consumption or feed wastage.

Table 26. Effect of Supplementation With Animal Proteins in Rations With Synthetic B_{12} and Antibiotics.
(From Series G, Table 24)

Ration Number	Soybean Meal	Fish Meal	Meat Scrap	8 week data			
				Weight		Feed Efficiency	
				Lbs.	% Dev.	Lbs.	% Dev.
5202	35.0	---	---	2.34	0.0	2.70	0.0
5206	28.0	5.0	---	2.44	+4.3	2.54	+6.0
5209	26.0	---	7.5	2.18	-6.8	2.78	-3.0

Ration 5206 with 5 percent of fish meal gave 4.3 percent faster growth and 6.0 percent greater feed efficiency than an all vegetable protein ration. This is in agreement with previous experiments, excepting Series F when fish meal of questionable origin was used and failed to give a response.

In this series, Ration 5209 with 7.5 percent of meat scrap gave inferior results, compared to an all soybean meal ration, of -6.8 percent on growth and -3.0 percent on feed efficiency. Previous series, with the exception of Series F, have shown meat scrap does not improve growth rate if the ration is adequate in minerals, riboflavin, and B_{12}. In series F, Table 18, the meat and bone scrap came from a small packing house in Kansas and gave a response above all vegetable protein rations.

Effects of Other Factors

When 10 percent wheat shorts was added to either all soybean meal protein rations or soybean + fish meal rations, it caused a slight but consistant decrease in growth rate of about 2. percent in batteries at 8 weeks of age.

Under floor brooding conditions up to 10 weeks there was no effect.

The addition of Rimocidin, a yeast and mold antibiotic, to ration 5210 containing antibiotic had no effect on growth rate but gave a slight improvement in feed efficiency. Insufficient trials were conducted on this to draw conclusions.

Series G, Floor Brooding Tests

Following battery tests on rations 5201 to 5210, four of these rations were selected for floor tests under farm or commercial broiler conditions. Each ration was tested on clean and old built-up litter using 100 straight run broiler type New Hampshire chicks in each lot.

Rations used in floor tests from Series G, Table 24, for complete rations:

5201—All soybean oil meal protein $+B_{12}$ and aureomycin.

5205—Same as 5201 with 10 percent of shorts replacing 8 percent of corn and 2 percent of soybean meal.

5206—Soybean-fish meal ration $+B_{12}$ and antibiotic.

5208—Same as 5206 with shorts replacing 8 percent of corn and 2 percent of soybean oil meal.

Table 27. Floor Brooding Tests on Clean and Built-up Litter

Ration Number	Type Litter	4 week data		10 week data		
		Weight Lbs.	Feed Eff.	Weight Lbs.	Feed Eff.	Percent Mortality
5201	Clean	.84	2.10	2.98	3.19	6.0
5201	Built-up	.82	2.07	2.93	3.16	2.0
5205	Clean	.79	2.12	2.86	3.20	2.0
5205	Built-up	.85	2.05	3.02	3.11	2.0
5206	Clean	.82	2.15	2.96	3.12	6.0
5206	Built-up	.82	2.03	3.04	3.10	8.0
5208	Clean	.82	2.20	2.97	3.24	5.0
5208	Built-up	.85	2.01	3.08	3.11	7.0
Average -	Clean	.82	2.14	2.94	3.19	4.75
Average -	Built-up	.84	2.04	3.02	3.12	4.75

Comparisons:

(1) By rations.—There was no significant difference in growth rate or feed efficiency in the rations compared. Rations with fish meal gave a very slight improvement over rations without fish meal but not as much as might be expected. The 10 percent of shorts did not reduce growth rate in this experiment as it did in battery experiments.

(2) By type of litter.—There was a slight improvement of about 2 percent in growth rate and feed efficiency on old litter used the previous spring for brooding chicks. This was not enough to be significant. However, it could be concluded that there were no harmful effects from the use of old litter that had remained idle for some time. Mortality of 4.75 percent was exactly the same on both types of litter.

SUMMARY AND CONCLUSIONS

1. The use of alfalfa meal in the ration tended to decrease growth rate. Each 1 percent of alfalfa meal over the 1½ percent level caused a 2 percent decrease in growth rate in both battery and floor reared chicks up to 8 weeks of age. This effect declines as the bird goes beyond 8 weeks of age.

2. Synthetic riboflavin can effectively replace alfalfa meal and dried milk as a source of riboflavin in chick rations.

3. Addition of meat scrap and dried milk to soybean meal rations has no appreciable effect on growth rate or feed efficiency if the ration contains sufficient riboflavin, protein and minerals. This conclusion, on the basis of average effect, does not always hold true as some lots of meat scrap appear to give some growth stimulus. Under average price relationships use of meat scrap and dried milk cannot be justified economically for growth stimulation in chick rations. Five percent of milk caused an average increase in growth rate of about 1½ percent.

4. Where no B_{12} or antibiotics are included in rations the addition of 5 pecent of fish meal gave a growth response in batteries at 8 weeks of age of from 10.0 percent to 14.8 percent or an average of 12.3 percent on three tests. Improved feed efficiency averaged 9.2 percent on these tests. Floor brooded chicks on the same type rations gave 18.4 percent faster growth with 5 percent fish meal over the basal when brooded on clean litter as compared to only 6.5 percent improvement with fish meal over basal ration where both groups were raised on old built-up litter.

5. Where B_{12} and antibiotics were included in basal ration of battery chicks, the addition of 5 percent fish meal resulted in from 2.5 percent to 5.4 percent with an average of 4.2 percent improved growth rate and 3.7 percent improved feed efficiency. Floor brooding tests on similar rations showed that the addition of 5 percent fish meal resulted in -4.0, +1.5, and +2.7 percent deviations in growth rate from control rations, indicating a high degree of variability of materials or response. Insufficient floor trials were run and the source of fish meal in these tests was too unreliable to make conclusive statements.

6. Fish meal was rather uniform in providing growth response due to its B12 values but was very irregular in providing additional growth response that might be due to unrecognized nutritional factors. A 60 percent Canadian herring meal gave the most uniform increase in growth response above what might be expected from the B_{12}.

7. Antibiotics gave a fairly uniform growth stimulation in battery chicks at eight weeks of age. This response was about 7 to 9 percent above control rations. Aureomycin or terramycin, at 8 to 10 grams per ton or procaine penicillin at a level of 2 grams per ton were equally effective.

8. From this entire series of tests we could conclude that B_{12} improved growth rate 6 to 9 percent, antibiotics an additional 7 to 10 percent and fish

meal an additional 0 to 5 percent over basal corn-soybean meal rations in batteries at 8 weeks of age.

9. In general, feed efficiency appeared to be a direct function of growth rate. That is, with each 1 percent increase in growth rate the feed efficiency was improved from 0.7 to 1 percent. There were exceptions.

10. The use of a "B" vitamin mix to supply extra niacin, choline chloride, pantothenic acid and folic acid to corn-soybean meal type rations resulted in a small but consistent and significantly improved growth rate of 1 to 3 percent and improved feed efficiency was almost always double the improved growth rate. It was not determined whether this difference was due to a wastage factor or change in actual feed conversion. It was economically sound to use extra "B" vitamins in broiler rations.

11. The use of wheat mill by-products decreased growth rate and feed efficiency. The use of 15 to 20 percent of wheat shorts and bran lowered energy level of ration about 2.6 Therms per 100 pounds of feed and resulted in about 2 to 2½ percent decrease in growth rate with a corresponding decrease in feed efficiency at 8 weeks of age in batteries.

12. The use of up to 10 percent of wheat shorts in rations of floor reared chicks up to 10 weeks of age did not appear to affect growth rate or feed efficiency.

13. The use of 0.5 percent of salt as compared to 1.0 percent of salt resulted in 7 to 10 percent less moisture in droppings with no significant difference in growth rate or feed efficiency.

14. Expeller process soybean oil meal was equal to solvent process meal of the same protein analysis if properly processed.

15. Iodinated casein or thyroprotein fed at a level of 0.04 percent continuously up to 8 weeks of age decreased growth rate as measured by body weight on both all vegetable protein and vegetable-animal protein rations with broiler type chicks. In slower growing strains there was no measurable effect.

16. Iodinated casein or thyroprotein at 0.04 percent level appeared to hasten the feathering of fast feathering birds but had no effect on the percentage of bare back chicks in slow feathering strains at 6 weeks of age.

17. Reducing the protein level of broiler ration to 16 or 18 percent after 8 weeks of age did not appear to affect the growth rate or feed efficiency of broiler birds and should be an economical practice.

18. Satisfactory broiler and chick rations can be designed from corn and soybean oil meal if properly supplemented with vitamins, minerals and antibiotics. This type of ration appears to be the most economical under present price relationships.

19. Old litter improved growth rate of floor brooded chicks when the ration was deficient in B_{12}. There was little or no difference in the growth rate on clean, as compared to old litter when the rations were adequate in all vitamins, proteins and minerals.