THE ROLE OF FAT IN THE GROWING CHICK

by

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INTRODUCTION

Working with chickens, nutritionists have concluded that fat in the ration is not essential; fats can be synthesized from carbohydrates. In the last two or three years, a few investigators have pointed out that chicks raised devoid of fat gained at pronouncedly slower rate than chicks receiving fat. Reiser and Couch (1949) stated that chicks on a completely synthetic diet required a small amount of fat or oil for proper growth.

The object of the research problem was to compare results obtained from chicks raised on purified diets containing no fat with chicks raised on diets at different levels of fat. The results were compared statistically to indicate if there were differences in growth.

Three different experiments were set up to include several types of rations. The different rations were diets that contained no fat or oil. Some of the different diets used, besides the no fat, were no fat plus defatted liver extract, no fat plus brewer's dried yeast, 20 percent linseed oil and different levels of fat or oil. Wide ranges of results were found from these diets and they are included in the experimental results.

Up to the present time, it has been felt that fat is not needed for the chick's growth. Yet the results in this study indicate that some fat may be required in the diet. When the growth figures of the different lots were tested statistically, by the F-test, the data showed a significant difference in the

growth, thus indicating differences between the no fat lots and the different levels of fat.

Linoleic, linolenic and sometimes arachidonic acids are known to be needed in small amounts for proper body functions of most animals, and they are assumed to be necessary for chickens. No measure was used to hydrogenate these unsaturated fatty acids to the saturated forms. Chicks in the no fat lots received small amounts of some unsaturated fatty acids from oil used to carry the fat-soluble vitamins. The results obtained in the following experiments did not indicate a need for hydrogenating the corn oil used. The corn oil acted as the carrier for the fat-soluble vitamins.

REVIEW OF LITERATURE

Using poultry as their experimental animal, MacArthur and Luckett (1915) did some early work with lipins. They stated there was an insoluble substance found in egg yolk, when treated with cold alcohol, that was necessary when feeding a synthetic diet. The diet consisted of casein, starch, lactose, lard, milk salts and this substance found in egg yolk which was presumed to be some type of lipin.

Warner and Edmond (1917) said the level of blood fat was in relation to the production of the hen. A hen in low production has a low blood fat level whereas a hen in high egg production has a high blood fat level.

The composition of the egg fat and depot fat of the fowl

was studied by Cruickshank (1934). She mentioned that when chicks received a normal cereal ration containing a protein supplement, the mixed fatty acids of the egg fat contained about 31 percent solid acid, 47-51 percent oleic acid, 15-19 percent linoleic, and 2 or 3 percent linolenic acid.

Furthermore Cruickshank stated that if a bird ingests a high percentage of saturated fatty acids, such as palm kernel oil or mutton fat, it caused a definite decrease in unsaturation of depot fat. Whereas, if the bird ingested high amounts of unsaturated fatty acids in the form of hempseed oil, it resulted in a marked and rapid increase in unsaturation.

Russell et al. (1940) reported on the fat requirements of the growing chick. An ordinary growing mash was fed which contained about 4 percent fat and a low fat diet was used which contained 0.025 to 0.074 percent fat. Growth between the two were 885 g and 769 g respectively for the fourteen-week period. The fact that the chicks did not show a marked nutritional failure led them to do more work on this subject.

The same type of rations were prepared with the low fat diet containing 0.098 percent fat and the normal ration containing 4.1 percent fat. The experiment was terminated at the end of fourteen weeks with a growth of 1,028 g for the 4.1 percent diet and the low fat diet as 993 g. They concluded that fat was not a nutritional factor for normal growth.

Russell et al. (1940) noticed that the depot fat of low fat groups was very white compared with a nice yellow color noted

in the group receiving the normal fat diet.

Davis and Upp (1941) conducted experiments to determine the quantitative requirements of chicks and mature birds fed mixed fats that occurred in natural feedstuffs. Chicks that were fed the fat-free ration grew somewhat slower than the chicks receiving fat, but the difference was made up at the time of maturity. With laying hens, there were greater variations in egg production which, in general, was correlated with an increase in the fat content of the ration.

Russell et al. (1941) reported that evidence was obtained in the case of certain hens on the low fat ration, that the greater part, if not all, the egg fat was synthesized from other constituents of the ration. They also stated there was a tendency toward a lower and less sustained egg production on the low fat ration, but there was no abrupt cessation of egg production as might be expected if an essential nutrition factor were absent.

Whitson et al. (1943) reported that chicks receiving a low fat diet (2.7 to 2.9 percent) utilized a significantly smaller percentage of the fat than chicks receiving medium (8.6 to 9.0 percent) or high (20.2 to 20.7 percent) fat diets. The fat in the low fat diet was typical of that present in poultry diets. The soybean oil that was added to the medium and high fat diets was an unsaturated fat, typical of many vegetable oils. More fat was excreted in the high fat diet than in the low diets, but the percentage of the fat in the diet excreted decreased

as the level of fat in the diet of the chick increased. They indicated that 80 to 85 percent of the fat in the low fat diet was absorbed while 94 to 95 percent of the fat in the high fat diet was absorbed.

Taylor et al. (1944) stated that a reduction of the fat content of the total ration from 3.12 to 1.56 percent had no unfavorable effect on mortality, egg production, fertility and hatchability or mortality of chicks during the first three weeks of life. Confirmation of these findings is furnished by the earlier work of Heywang (1943) using rations of a semi-synthetic nature and supplying most of the fat in the form of added corn oil.

Reiser and Pearson (1948) used purified fat diets for their tests. The purified diets consisisted of no fat, 20 percent Wesson oil, 20 percent lard, 20 percent Spry and a control. The results showed that the chicks on 20 percent lard decreased growing on the 5th day and the no fat, and Spry, and Wesson oil groups gained very slowly. The control grew at a normal rate.

MacGregor and McGinnis (1948) reported that linseed meal contains a toxic substance which depresses chick growth when added to an adequate diet. However, when water treated linseed meal was used in an adequate diet, this depression of growth did not occur.

In recent work carried out by Reiser and Couch (1949) the following diets were used on day-old chicks: (a) Practical

all-mash chick starter, (b) purified fat-free diet and (c) purified fat-free diet plus 4 percent Wesson oil. The experiment was performed with intact chicks and with those from which the residual yolks had been removed in view of the possibility that their absence might exaggerate any fat deficiency symptoms. It was found that the groups on the practical and purified Wesson oil rations gained at the same rate. The groups on the purified fat-free ration gained at pronouncedly slower rate. The chicks from which the residual yolks had been removed showed no handicap, the rates of gain being approximately the same as in the unoperated groups.

MATERIAL AND METHODS

Day-old Kansas White Rock chicks were used in Experiments I, II, and III. The chicks were hatched at the College Poultry Farm.

Experiment I

In Experiment I, 100 chicks were randomized into 10 lots of 10 each and wing banded. They were brooded in an electric battery-brooder where they were fed for 28 days. The temperature of the brooder room was maintained between 70° to 75° F. The individual heating units of the brooder were adjusted to the comfort of the chicks.

Feed was mixed one day before the chicks were hatched. The synthetic diets for this experiment are listed in Table 1.

The Wesson salt mix for Experiments I, II, and III was prepared from chemically pure compounds and was made up several days before using. The salt mixture is listed in Table 2.

Table 1. Experiment I, composition of the diets.

Ingredients	Diet numbers									
	1	2	3	4	5	6	7	8	9	10
	No fat	No fat + APF	½% fat	1% fat	2% fat	4% fat	10% fat	20% fat	20% LO + Eth	20% LO
Cerelose	68.48 lb	68.47 lb	67.97 lb	67.47 lb	66.42 lb	64.40 lb	57.76 lb	48.33 lb	48.33 lb	48.33 lb
Casein	18.00 "	18.00 "	18.00 "	18.00 "	18.00 "	18.00 "	18.00 "	18.00 "	18.00 "	18.00 "
Celluflour	5.00 "	5.00 "	5.00 "	5.00 "	5.00 "	5.00 "	5.00 "	5.00 "	5.00 "	5.00 "
Wesson salt	4.00 "	4.00 "	4.00 "	4.00 "	4.00 "	4.00 "	4.00 "	4.00 "	4.00 "	4.00 "
Cystine	144.61 g	144.61 g	144.61 g	144.61 g	144.61 g	144.61 g	144.61 g	144.61 g	144.61 g	144.61 g
Glycine	366.73 "	366.73 "	366.73 "	366.73 "	366.73 "	366.73 "	366.73 "	366.73 "	366.73 "	366.73 "
i-Inositol	45.50 "	45.50 "	45.50 "	45.50 "	45.50 "	45.50 "	45.50 "	45.50 "	45.50 "	45.50 "
Choline	91.00 "	91.00 "	91.00 "	91.00 "	91.00 "	91.00 "	91.00 "	91.00 "	91.00 "	91.00 "
Niacin (supplied by "Vitab")	none	none	none	none	none	none	none	none	none	none
Riboflavin	389.54 mg	389.54 mg	389.54 mg	389.54 mg	389.54 mg	389.54 mg	389.54 mg	389.54 mg	389.54 mg	389.54 mg
p-Amino benzoic a.	136.51 "	136.51 "	136.51 "	136.51 "	136.51 "	136.51 "	136.51 "	136.51 "	136.51 "	136.51 "
Folic acid	36.40 "	36.40 "	36.40 "	36.40 "	36.40 "	36.40 "	36.40 "	36.40 "	36.40 "	36.40 "
Biotin (supplied by "Vitab")	none	none	none	none	none	none	none	none	none	none
Pantothenic acid	341.55 "	341.55 "	341.55 "	341.55 "	341.55 "	341.55 "	341.55 "	341.55 "	341.55 "	341.55 "
Thiamine	84.23 "	84.23 "	84.23 "	84.23 "	84.23 "	84.23	84.23 "	84.23 "	84.23 "	84.23 "
APF	none	23.00 g	23.00 g	23.00 g	23.00 g	23.00 g	23.00 g	23.00 g	none	none
Corn oil	none	none	226.52 "	453.04 "	906.07 "	4.00 lb	10.00 lb	20.00 lb	none	none
"Vitab"[1]	1,386.10 g	1,386.10 "	1,386.10 "	1,386.10 "	1,386.10 "	1,386.10 g	1,386.10 g	1,386.10 g	1,386.10 g	1,386.10 g
Linseed oil	none	none	none	none	none	none	none	none	20.00 lb	20.00 lb
Ethanolamine	none	none	none	none	none	none	none	none	100.00 g	none
Vit. A)										
Vit. D_3)										
Vit. K - Menadione)	- Given orally twice weekly[2]									
Vit. E)										
Total (lbs.)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[1]"Vitab" each cc. of this solution contains:

Thiamine	150.0 micrograms
Riboflavin	10.0 "
Pantothenic acid	275.0 "
Pyridoxin	150.0 "
Niacin	2000.0 "
Choline	8000.0 "
i-Inositol	6000.0 "
Biotin	1.2 "

[2]Vitamin mixture - administered orally - first week 1 drop twice weekly, second week 2 drops twice weekly, third week 3 drops twice weekly, fourth week 4 drops twice weekly. This mixture was made up of 327 g. of corn oil, 40 mg. of crystalline D_3, 15 g. of vitamin A, and 5 g. of vitamin E concentrate, and 200 mg. of Menadione. Each gram of vitamin A contains 200,000 units, the vitamin E concentrate contains 34 percent of mixed natural tocopherols, and each g. of crystalline D_3 contains 55,000 A.O.A.C. chick units. The vitamin mixture was stored in a refrigerator (electric) at the college poultry farm.

Table 2. Composition of Wesson salt mixture.

Ingredients	4 pounds : grams	100 pounds
NaCl	185.6400	4,564.89
KCl	212.1700	5,217.26
KH_2PO_4	548.1000	13,477.78
$Ca_3(PO_4)_2$	263.4400	6,477.99
$CaCO_3$	371.2900	9,130.02
$MgSO_4$ (anhydride)	159.1800	3,914.24
Fe Pyrophosphate	105.2000	2,586.87
$MnSO_4$ (anhydride)	0.3536	8.70
$K_2Al_2(SO_4) \cdot 24\ H_2O$	0.1591	3.91
$CuSO_4 \cdot H_2O$	0.6894	16.96

First, the principle components of the diets were mixed together. Cerelose was added, then casein, celluflour, Wesson salt, cystine, glycine and the water-soluble vitamins plus a commercial compound known as "Vitab". The latter was added to the diets to supply some of the water-soluble vitamins. After the preliminary mixing, the mixture was divided into 10 equal batches by the use of a beam-balance scale. Animal protein factor was added to all batches except diets 1, 9 and 10 at the rate of 23 g per 100 pounds of diet.

Next corn oil was added to diet 3 at the rate of 1/2 percent of the diet plus enough cerelose to make an even 7.2 pounds of feed. Diet 4 received 1 percent corn oil plus cerelose. Diets for lots 5, 6, 7, and 8 received corn oil at 2, 4, 10, and 20 percent respectively plus the needed cerelose to make the 7.2 pounds of diet for each lot. To diets 9 and 10 was added linseed oil at the rate of 20 percent of the diet plus cerelose to make the needed weight. Ethanolamine was added to diet 9 in the

proportion of 1 g per pound of feed. Ethanolamine was used to help counteract the action of the linseed oil.

The fat-soluble vitamins A, D_3, K and E were mixed into one solution and given orally twice weekly to each chick by medicine dropper. The first week the chicks received 1 drop twice a week and so on until the fourth week when they received 4 drops twice a week.

The fat-soluble vitamins were mixed into the vitamin mixture by the following procedure: (1) By placing 100 cc of corn oil into a flask and adding crystalline D_3 to the corn oil and mixing. (2) Then 200 mg of menadione, the source of vitamin K, was added and stirred until completely dissolved. (3) Vitamins A and E were added. (4) Corn oil was used to rinse all containers and it was then put into the flask of solution and (5) Enough corn oil was added to the vitamin mix to make up a solution of 327 g.

Chicks were weighed individually at the beginning of the experiment and each week thereafter until the chicks were 4 weeks of age. Weekly feed consumption records were also determined.

Experiment II

Experiment II, 100 chicks were randomized into 10 lots of 10 chicks each and wing banded.

Feed for this experiment was mixed two days before the chicks were hatched. The ingredients were essentially the same as in Experiment I, except the amino acid, arginine, was added at the

rate of 98 g per 100 pounds of feed. One pound of gelatin per 100 pounds of feed was added also. Amount of riboflavin, folic acid and pantothenic acid were doubled in this experiment in an effort to assure maximum growth. Pure crystalline biotin was also added to the diets. An ultra-violet sunlamp was used to give the chicks more vitamin D by irradiation. Diet 1 was the no fat diet and diet 2 was the no fat plus Animal protein factor diet. Diet 3 in this experiment was made up of the basal mixture of no fat plus 2 percent defatted liver extract. Diet 4 consisted of the basal mixture (no fat) plus 5 percent brewer's dried yeast. These diets are listed in Table 3. Lot 10 was fed a standard broiler ration and contained approximately 4.88 percent fat. The diet included meat and bone scraps and fish meal as the source of animal protein. This diet was the control group of the experiment and is listed in Table 4.

The basal mixture for Experiment II was prepared the same way as in Experiment I. Since diet 10 was not a synthetic ration, it was mixed separately.

Chicks for Experiment II were weighed at the beginning of the test and each week thereafter until 4 weeks of age. Weekly feed consumption records were again determined.

In this experiment the chicks were again brooded in an electric battery brooder. Ten chicks were placed in each section. The room was regulated to a temperature of 70° to 75° F. The overhead heating units were the contact type and as the chicks grew the hovers were raised. Fat-soluble vitamins were given to the chicks orally twice weekly and the amount given was increased weekly by two drops.

Table 3. Experiment II, composition of diets.

Ingredients	Diet numbers 1	2	3	4	5	6	7	8	9
	No fat	NF + APF	NF + liver	NF + yeast	½% fat	1% fat	2% fat	4% fat	10% fat
Cerelose	67.97 lb	67.96 lb	65.96 lb	62.96 lb	67.46 lb	66.97 lb	65.97 lb	63.97 lb	57.97 lb
Casein	18.00 "	18.00 "	18.00 "	18.00 "	18.00 "	18.00 "	18.00 "	18.00 "	18.00 "
Gelatin	1.00 "	1.00 "	1.00 "	1.00 "	1.00 "	1.00 "	1.00 "	1.00 "	1.00 "
Celluflour	5.00 "	5.00 "	5.00 "	5.00 "	5.00 "	5.00 "	5.00 "	5.00 "	5.00 "
Wesson salt[1]	4.00 "	4.00 "	4.00 "	4.00 "	4.00 "	4.00 "	4.00 "	4.00 "	4.00 "
Cystine	144.61 g	144.61 g	144.61 g	144.61 g	144.61 g	144.61 g	144.61 g	144.61 g	144.61 g
Glycine	366.73 "	366.73 "	366.73 "	366.73 "	366.73 "	366.73 "	366.73 "	366.73 "	366.73 "
Arginine	98.00 "	98.00 "	98.00 "	98.00 "	98.00 "	98.00 "	98.00 "	98.00 "	98.00 "
i-Inositol	45.50 "	45.50 "	45.50 "	45.50 "	45.50 "	45.50 "	45.50 "	45.50 "	45.50 "
Choline	91.00 "	91.00 "	91.00 "	91.00 "	91.00 "	91.00 "	91.00 "	91.00 "	91.00 "
Niacin	4,550.00 mg	4,550.00 mg	4,550.00 mg	4,550.00 mg	4,550.00 mg	4,550.00 mg	4,550.00 mg	4,550.00 mg	4,550.00 mg
Riboflavin	800.00 "	800.00 "	800.00 "	800.00 "	800.00 "	800.00 "	800.00 "	800.00 "	800.00 "
p-amino benzoic a.	136.50 "	136.50 "	136.50 "	136.50 "	136.50 "	136.50 "	136.50 "	136.50 "	136.50 "
Folic acid	72.80 "	72.80 "	72.80 "	72.80 "	72.80 "	72.80 "	72.80 "	72.80 "	72.80 "
Biotin	4.54 "	4.54 "	4.54 "	4.54 "	4.54 "	4.54 "	4.54 "	4.54 "	4.54 "
Pantothenic acid	668.00 "	668.00 "	668.00 "	668.00 "	668.00 "	668.00 "	668.00 "	668.00 "	668.00 "
Thiamine	200.00 "	200.00 "	200.00 "	200.00 "	200.00 "	200.00 "	200.00 "	200.00 "	200.00 "
APF	none	23.00 g	none	none	23.00 g	23.00 g	23.00 g	23.00 g	23.00 g
Corn oil	none	none	none	none	227.00 "	1.00 lb	2.00 lb	4.00 lb	10.00 lb
"Vitab"[2]	1,086.00 g	1,086.00 g	1,086.00 g	1,086.00 g	1,086.00 "	1,086.00 g	1,086.00 g	1,086.00 g	1,086.00 g
Defatted liver extract	none	none	2.00 lb	none	none	none	none	none	none
Brewer's dried yeast	none	none	none	5.00 lb	none	none	none	none	none
Vit. A Vit. D_3 Vit. K - Menadione Vit. E	- Given orally twice weekly[3]								
Total (lbs.)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[1]Changes in Wesson salt (Table 2) - doubled amount of $CaCO_3$, $CuSO_4 \cdot H_2O$ and added 16 g of cobalt sulfate per 100 pounds of mixture.

[2]"Vitab" - check footnote on Table 1.

[3]Vitamin mixture - check footnote on Table 1.

[4]Ultra-violet light use 20-30 minutes per day to supplement crystalline D_3.

Table 4. Experiment II, composition of diet 10.

Ingredients	: Broiler ration, lbs.
Ground yellow corn	52.0
Wheat bran	3.6
Dehydrated alfalfa	0.9
Meat and bone scraps	7.8
Fish meal	1.4
Soybean meal (41% protein)	31.9
$CaCO_3$	0.9
NaCl	0.5
Steamed bone meal	0.9
$MnSO_4$	15.0 g
Delsterol (source of vitamin D_3)	37.0 "
Riboflavin	5.0 "
Prot A	91.0 "
Total	100.0 lbs

Experiment III

Experiment III had 5 lots of chicks with 5 chicks per lot. These 25 chicks were sexed Kansas White Rock cockerels. They were wing banded and selected, without bias, for the 5 lots.

Feed for this experiment was the same as that used in Experiment II; however, the no fat, 1/2 percent, 1 percent, 2 percent, and 10 percent fat diets were used. These diets are found in Table 5.

Chicks for this experiment were weighed at the beginning of the test and weekly thereafter for 3 weeks. Weekly feed consumption was checked at the same time the chicks were weighed.

An electric battery brooder was used in a room temperature kept at approximately 70° to 75° F. Feed and water were available continuously from the first day.

Table 5. Experiment III, composition of diets.

Ingredients	Diet Numbers 1 No fat	2 ½% fat	3 1% fat	4 2% fat	5 10% fat
Cerelose	67.97 lb	67.46 lb	66.97 lb	65.97 lb	57.97 lb
Casein	18.00 "	18.00 "	18.00 "	18.00 "	18.00 "
Gelatin	1.00 "	1.00 "	1.00 "	1.00 "	1.00 "
Celluflour	5.00 "	5.00 "	5.00 "	5.00 "	5.00 "
Wesson salt[1]	4.00 "	4.00 "	4.00 "	4.00 "	4.00 "
Cystine	144.60 g	144.60 g	144.60 g	144.60 g	144.60 g
Glycine	366.70 "	366.70 "	366.70 "	366.70 "	366.70 "
Arginine	98.00	98.00 "	98.00 "	98.00 "	98.00 "
Niacin	4,550.00 mg	4,550.00 mg	4,550.00 mg	4,550.00 mg	4,550.00 mg
Riboflavin	800.00 "	800.00 "	800.00 "	800.00 "	800.00 "
p-Amino benzoic acid	136.50 "	136.50 "	136.50 "	136.50 "	136.50 "
Folic acid	72.80 "	72.80 "	72.80 "	72.80 "	72.80 "
Biotin	4.54 "	4.54 "	4.54 "	4.54 "	4.54 "
Pantothenic acid	668.00 "	668.00 "	668.00 "	668.00 "	668.00 "
Thaimine	200.00 "	200.00 "	200.00 "	200.00 "	200.00 "
i-Inositol	45.50 g	45.50 g	45.50 g	45.50 g	45.50 g
Choline	91.00 "	91.00 "	91.00 "	91.00 "	91.00 "
APF	none	23.00 "	23.00 "	23.00 "	23.00 "
Corn oil	none	227.00 "	1.00 lb	2.00 lb	10.00 lb
"Vitab"[2]	1,086.00 g	1,086.00 "	1,086.00 g	1,086.00 g	1,086.00 g
Vit. A) Vit. D_3[4]) Vit. K - Menadione) Vit. E)	- Given orally twice weekly[3]				
Total (lbs.)	100.00	100.00	100.00	100.00	100.00

[1]Changes listed in footnotes of Table 3.

[2]Check footnotes of Table 1.

[3]Check footnotes of Table 1.

[4]Check footnotes of Table 3.

RESULTS

Experiment I

Diets. The diets for the preliminary experiment included a no fat diet, no fat plus APF, 1/2, 1, 2, 4, 10, 20 percent fat diets, and two 20 percent linseed oil diets with one having ethanolamine added. With these different diets, it was hoped that the amount of fat needed to produce proper growth for the growing chick could be found.

Lots 1 and 2 of this experiment were the no fat diets, and thus the consistency of the feed was very dry and dusty. Diets 3, 4, 5 and 6 seemed to have had the best texture of the groups, while the other four lots did not eat the diets too readily.

Table 6. Experiment I, body weight and mortality for Kansas White Rock chicks for 28 days.

Diets	Average weights (grams)	Mortality
1 - No fat	55.3	5
2 - No fat + APF	66.3	2
3 - 1/2% fat	59.3	1
4 - 1% fat	58.0	2
5 - 2% fat	57.9	5
6 - 4% fat	57.9	1
7 - 10% fat	67.2	3
8 - 20% fat	72.0	3
9 - 20% linseed oil + ethanolamine	49.8	4
10 - 20% linseed oil	51.3	4

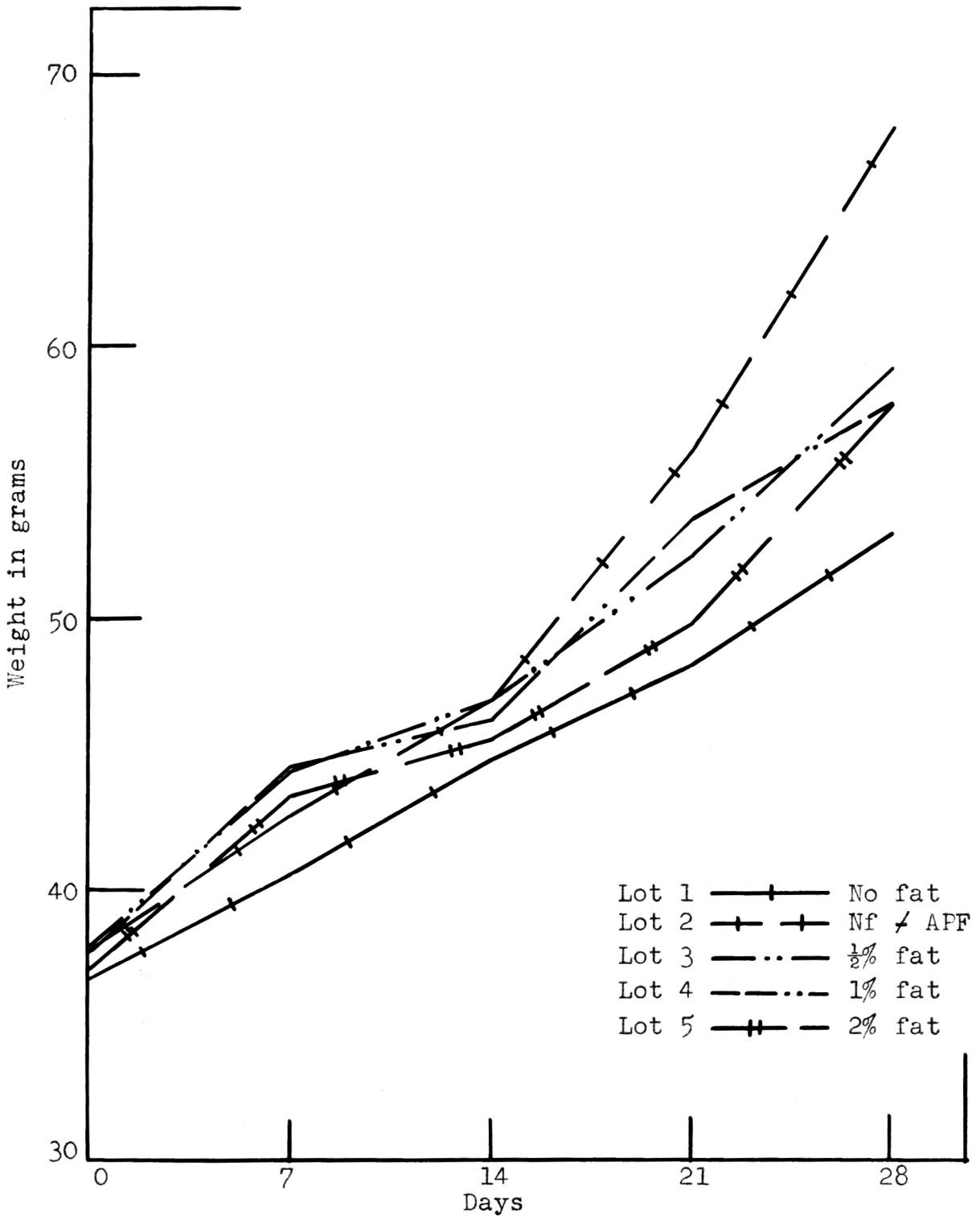

Fig. 1. Experiment I, lots 1 to 5, growth for Kansas White Rock chicks for 28 days.

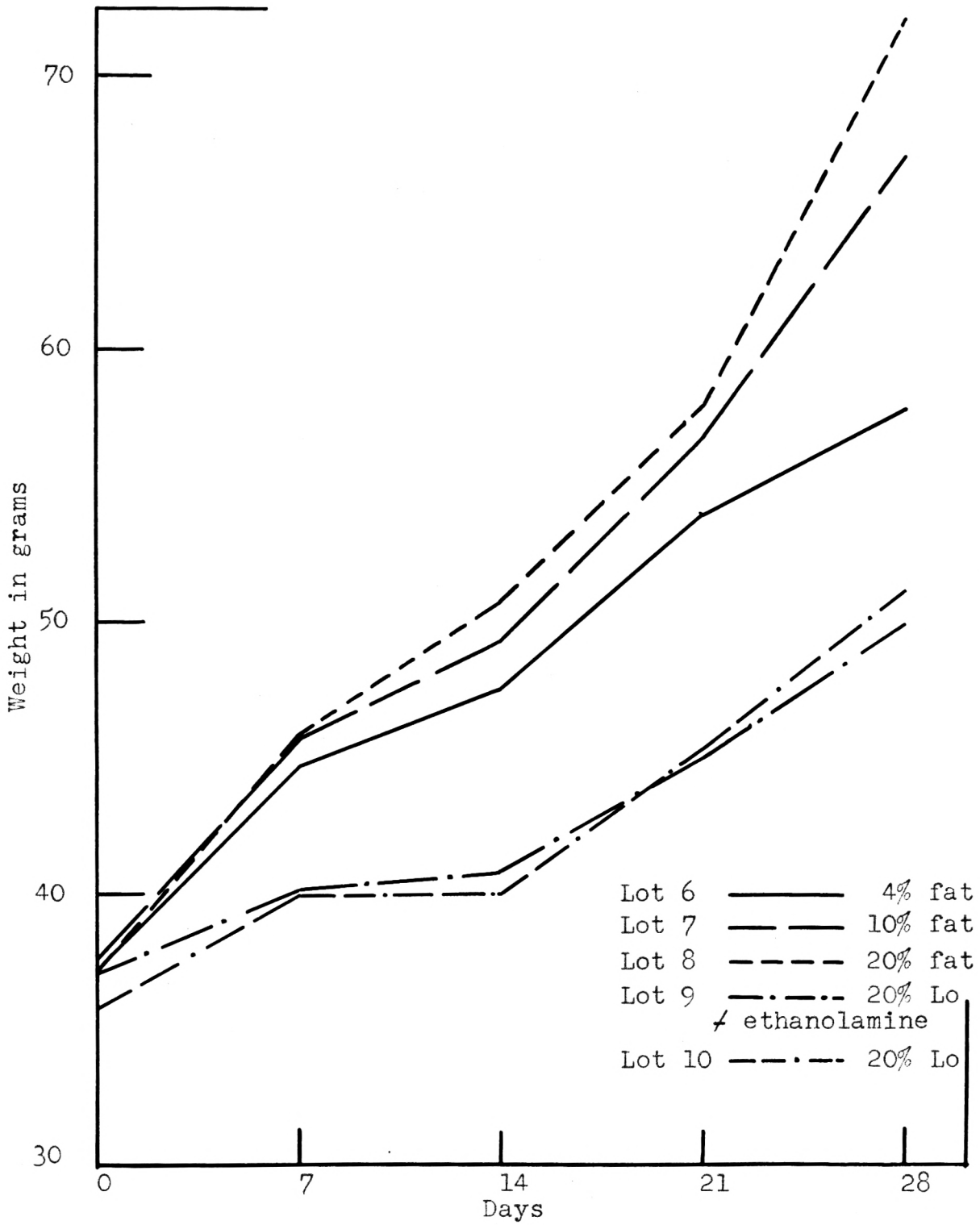

Fig. 1 (concl). Experiment I, lots 6 to 10.

Growth, 28-Day Weights. Growth for this experiment, in all lots, was very poor and no reliable results could be used. Yet when the average 28-day growths are compared, it would seem to indicate that fat was required for growth, Table 6 and Fig. 1 for the growth on Experiment I. When analyzed by the F-test for significance, it was disclosed that not enough growth had been made by 28 days to show any significant difference between the growth of the lots as indicated in Table 7.

Table 7. Experiment I, analysis of variance of growth for Kansas White Rock chicks for 28 days.

Sources of variance	D/F	Mean of squares	Est. of variance
Between	9	3,193.67	354.85
Individual	60	14,037.83	233.96
Total	69	17,231.50	

Lot 1 only averaged 55.3 g while lot 8 averaged 72.0 g. All the lots receiving corn oil, as the source of oil, gained more than lot 1. The lots receiving high levels of linseed oil were below the growth of lot 1. The indication was that linseed oil, at high levels, even with the aid of ethanolamine, resulted in poorer growth than rations receiving no fat.

The no fat plus APF showed a gain of 66.3 g or 11 g greater gain than the no fat diet with no APF added. This diet had better growth than all the other diets except the 10 percent and 20 percent fat rations.

Feathering and General Appearance. Careful studies were

made of the feathering and general appearance of the chicks in each lot. The feathering of all the chicks was very slow in appearing. When the feathers did develop, they were very ragged and curled outward and backward. This would signify that some nutritional factor or factors were lacking for proper growth of feathers. It appeared that the vitamins, folic acid and biotin were lacking in sufficient amounts.

The condition of the chicks' down appeared to be very dry and rough in lots 1, 8, 9 and 10. The feathers that were present were very brittle and dry besides being curled. In the other lots, the down and feathers of the chicks seemed to be oily, yet ragged and curled.

It was noticed, when handling the chicks, that the upper mandibles and sometimes the tarsometatarus were soft and pliable. This would seem to denote a lack of vitamin D. During the third week a small amount of "Halibut-liver oil concentrate" was given to each chick. This did not improve the condition of these bones. The diseased condition must have been too advanced for the vitamin A and D concentrate to be of help in correcting this.

Mortality. Mortality in this experiment was very heavy. It could have been due to improper growth of the chicks. Five chicks each were lost from lots 1 and 5 during the 28-day period, whereas 4 chicks were lost from lots 9 and 10 and 3 chicks were lost from lots 7 and 8.

It was noted that the heaviest loss of chicks during the 28-day period was around the second and third week of the

experiment. Some of the dead chicks indicated symptoms of Newcastle disease. It was noted also that some of the dead chicks had very soft upper mandibles. This symptom indicated a vitamin D deficiency.

Chicks that died, for the most part, were pasted-up around the vent and showed some emaciation. It was indicated that the purified diets lacked some growth factor or factors and perhaps was too high in carbohydrates. Necropsies were preformed on some of the chicks, but no diseased condition was noted except birds suspected of having Newcastle disease. This would reveal that some nutritional factor or factors were lacking.

Experiment II

Diets. The diets for this experiment were changed from Experiment I. The changes were made in an attempt to correct for some unknown nutritional factor that appeared to be deficient in the first experiment. A regular broiler ration was included to compare the growth of chicks on synthetic diets with that of a regular broiler diet. The rate of growth is listed in Table 8.

Table 8. Experiment II, average growth each week for Kansas White Rock chicks for 28 days.

Lots	Beginning	7 days	14 days	21 days	28 days
			grams		
1 - No fat	38.35	57.60	71.45	99.60	127.00
2 - Nf + APF	38.45	63.20	77.70	115.25	151.75
3 - Nf + L	40.25	58.56	76.90	119.55	170.89
4 - Nf + Y	39.25	63.25	89.30	144.89	189.50
5 - ½% fat	39.85	59.35	73.80	124.25	165.33
6 - 1% fat	39.70	56.05	69.70	101.11	149.38

Table 8 (concl.).

Lots	Beginning	7 days	14 days	21 days	28 days
			grams		
7 - 2% fat	38.15	56.25	70.40	113.81	150.14
8 - 4% fat	37.10	55.20	68.85	96.79	133.14
9 - 10% fat	39.05	59.25	74.25	97.50	137.20
10 - Control	37.90	50.70	78.10	126.31	212.75

The basal mixture was changed in this experiment and to it was added the amino acid, arginine which is known to be needed for rapid and normal growth of the young. Gelatin was added at the rate of 1 pound per 100 pounds of feed.

The known vitamins which refer directly to growth were doubled in this experiment. This was done to make the level of the vitamins far above the minimum requirements for maximum growth as indicated by the National Research Council. Riboflavin was increased from the original 400 mg used in Experiment I to 800 mg per 100 pounds of feed. The riboflavin used in all three experiments was in the pure form with no carriers added. Folic acid was doubled also from 36.4 mg 72.8 mg per 100 pounds of feed. The 72.8 mg of folic acid was in powder form and in Experiments II and III it was dissolved in water. The water solution was then added to the basal mixture as the feed mixer was turning. Biotin was added at the rate of 4.54 mg of pure crystalline biotin per 100 pounds of feed. This too was mixed into the basal mixture as a water solution. The method of dissolving the vitamins in water was used to insure more uniform distribution of

the vitamins in the basal mixture. Pantothenic acid was increased in Experiments II and III to 668 mg. All the water-soluble vitamins in the three experiments were in the pure crystalline form except niacin which was in high amounts in the commercial product "Vitab".

After these diets had been fed for 28 days, it was noted that the addition of arginine and gelatin and the doubling of the growth vitamins resulted in better growth and general appearance of the birds.

An ultra-violet lamp was included in this experiment to correct the vitamin D deficiency noted in Experiment I. An S-4 sunlamp was used at the rate of 20 to 30 minutes per day. This was to supplement the vitamin D_3 that the chicks received in the vitamin mixture. By the use of the sunlamp, all symptoms of the vitamin D deficiency were corrected.

Growth, 28-Day Weights. The growth for Experiment II was much better and more informative than in Experiment I. The growth of Kansas White Rock chicks is compared in Table 8 and in Fig. 2. When analyzed by the F-test it showed enough variation between the lots to indicate a highly significant difference in growth as indicated in Table 9.

Table 9. Experiment II, analysis of variance of growth for Kansas White Rock chicks for 28 days.

Sources of variance	D/F	Mean of squares	Est. of variance
Between	9	51,160.85	5,683.54
Individual	66	59,338.15	899.06 **
Total	74	110,509.00	

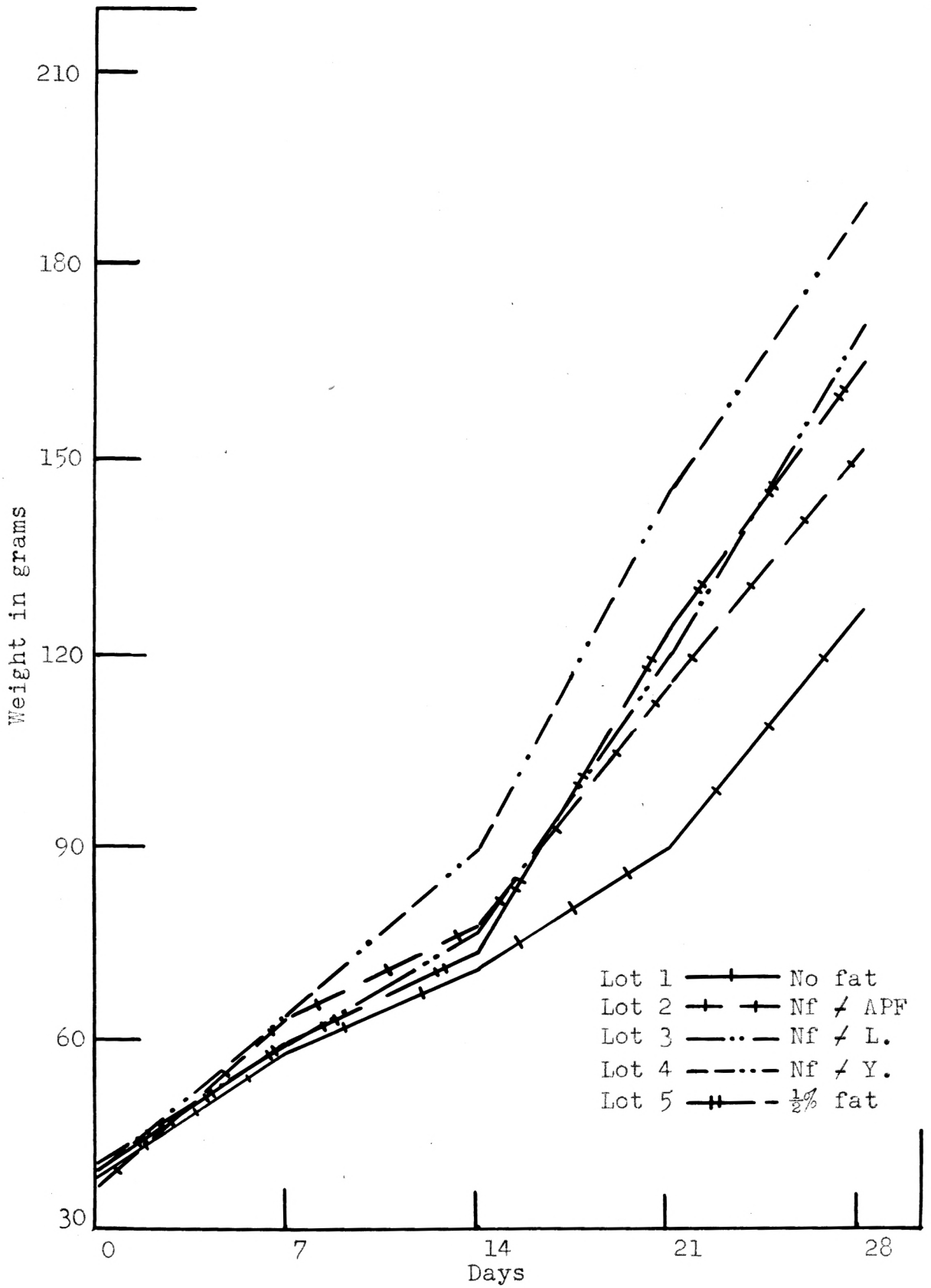

Fig. 2. Experiment II, lots 1 to 5, growth for Kansas White Rock chicks for 28 days.

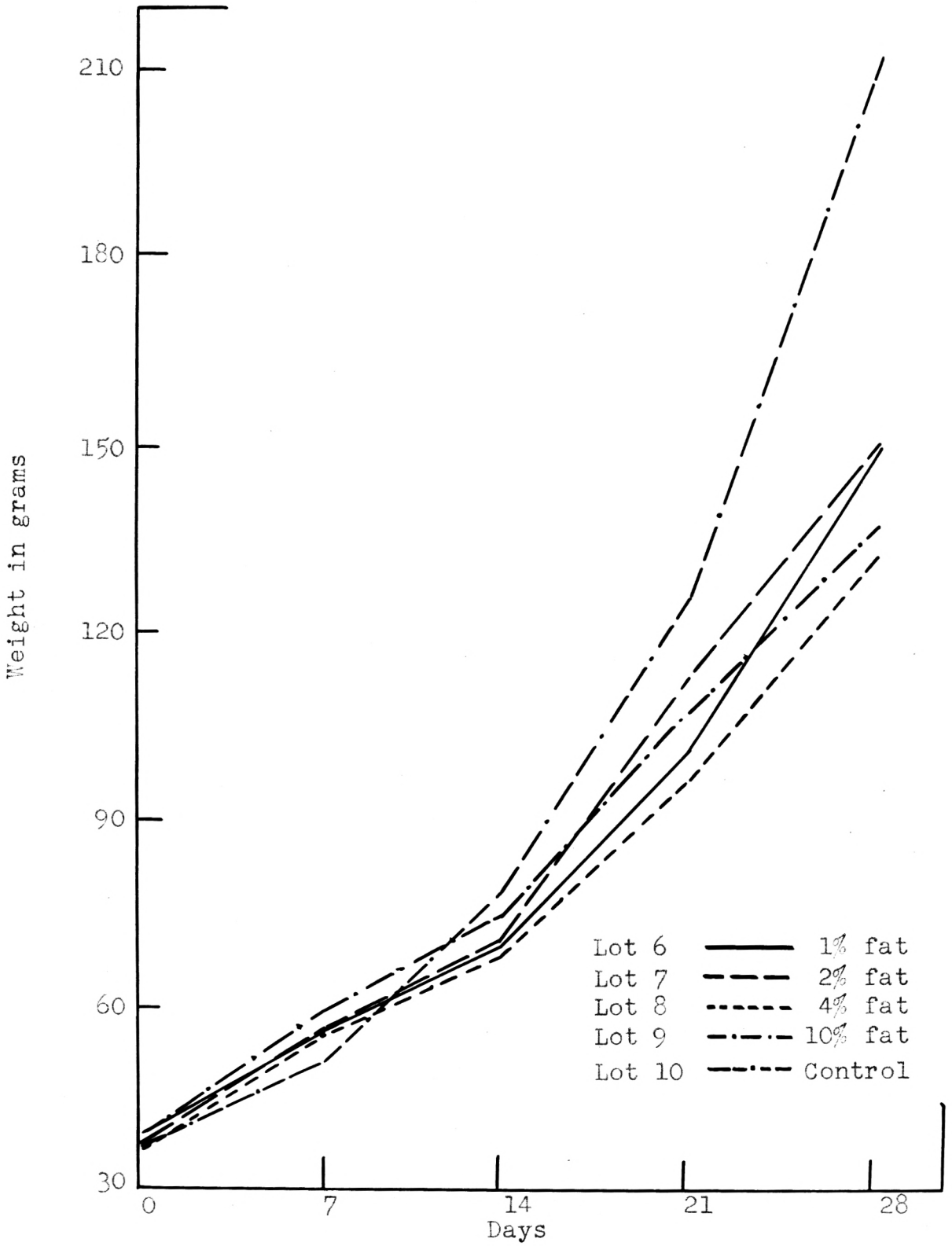

Fig. 2 (concl.). Experiment II, lots 6 to 10.

Birds in lot 1 which received no oil or APF showed a much slower rate of growth, especially after the first 7 days. At the beginning of the experiment, lot 1 averaged over 38 g and lot 2 averaged about the same, but at the end of the first 7 days lot 1 weighed 57.6 g and the second lot weighed 63.2 g. The growth of all the birds in the experiment was retarded the second week because of an outbreak of Newcastle disease. This can be shown very clearly in Fig. 2. By the slowing down of growth the second week, the 28-day weights are below what the normal growth should be.

Lot 1 averaged 71.4 g the second week, 99.6 g the third, and 127 g the last week, while lot 2 averaged 77.7 g for the second week, 115.2 g the third and 151.7 g the last week. When the 28-day weights were compared by the t-test, it showed that there were significant differences at the 5 percent level.

Lots 3 and 4, which are basal mixtures plus liver and yeast, respectively, had a very marked increase in growth over the no fat group. When 2 percent liver was added and compared with the no fat group, an increase of weight was shown to be 53.9 g. Yeast was added at 5 percent of diet and increased the average chick's weight by 62.5 g. When checked by the t-test for significance, the test indicated that both lots were highly significant when compared with the no fat lot as indicated in Table 10. These two lots were included in this experiment to indicate if the basal mixture was devoid of certain nutritional factors. It was not known whether the liver and yeast had unknown factors

Table 10. Experiment II, t-test of growth for Kansas White Rock chicks for 28 days.

Diets compared	t-test
No fat and no fat + APF	2.08 *
No fat and 2% defatted liver	3.02 **
No fat and 5% brewer's dried yeast	3.94 **
No fat and ½% fat	2.29 *
No fat and 1% fat	1.00
No fat and 2% fat	1.61
No fat and 4% fat	0.50
No fat and 10% fat	1.00
No fat and control	3.90 **

present necessary for growth, or if liver and yeast supply some of the essential substances needed to replace the fats for normal chick growth. Table 8 and Fig. 2 clearly indicate the increase accomplished by these two ingredients.

When oil was added at the rate of 1/2 percent, a significant growth increase was noted. The 1/2 percent oil was added to a basal diet plus APF. This lot increased more rapidly than the no fat lot after the first 7 days. The chicks in this lot also were slowed down in growth due to an outbreak of a respiratory disease. At the end of the third week the 1/2 percent oil lot outweighed the no fat lot by 24 g and the end of the experiment 38.3 g.

At the end of the experimental period, the growth rates were checked for lots 6, 7, 8 and 9 and were compared with lot 1. The comparison showed no significant results by the use of the t-test. Even when nonsignificant differences were found, the growth of these lots was much greater than the no fat lot. As

has been stated before, lot 1 weighed 127 g at the end of the 28-day period, while lot 6 weighed 149.4 g, lot 7 - 150.1 g, lot 8 - 133.1 g and lot 9 - 137.2 g. These figures led the author to believe that oil or fat was needed for the chicks' growing ration even though not proved statistically. When the extra growth was compared with the cost of needed oil, it justified the use of oil or fat in the chick's diet. It should be noticed that 4 percent or more oil in a ration tends to decrease growth.

A control lot was used to compare the growth of chicks on a normal broiler ration to chicks on a completely synthetic diet. The figures clearly indicate that baby chicks did not grow as well on the synthetic diets used in this experiment as on a normal broiler ration. When weights were compared, the control lot outgained the no fat lot by 95 g. When treated for significance by the t-test, a wide variation in growth was indicated by a highly significant figure as listed in Table 10. Lot 10 outgrew all the other lots, but only by 23.2 g when compared with the purified diet supplemented with yeast. This would tend to denote that yeast has some unknown factor present that is needed for growth that was not included in the basal mixture. Growth curves are listed in Fig. 2 and the 28-day weights in Table 8.

Ultra-violet light was given to all chicks in all groups during Experiment II.

Administration of the fat-soluble vitamins was continued as in Experiment I. Chicks received the oil mixture twice weekly.

The chicks during the 28-day growing period showed no signs of any fat-soluble vitamin deficiencies. Each week the administration of oil was increased at the rate of 2 drops weekly. At the end of the 28 days each chick was receiving 4 drops of oil mixture twice weekly.

The salt mixture used in Experiment II was changed somewhat from Experiment I. This involved the inclusion of 372 g of calcium carbonate to 4 pounds of mix, doubling the amount of copper sulfate and cobalt sulfate was added at the rate of 1 g per 4 pounds of mix. The addition of calcium carbonate improved the percent calcium-phosphorus in the diet. Cobalt and copper were added to prevent any anemic condition.

Feathering and General Appearance. Feathering in Experiment II was superior to the first experiment, yet it must be stated that it still was not normal. The curled and frilled feathering that was noted in Experiment I was lacking in this test. The feathers grew normally and did not show the slow rate of growth as in the first test. The feathers appeared to be ragged in most lots; this could have been caused by an upset in the chick's physiological functions during the attack of Newcastle disease.

Feathering in Experiment II was studied carefully and some of the results are shown on Plates I, II and III. Fig. 1 shows the primary wing feathers of a bird from the no fat lot. It should be noticed how poor the feathers developed when chicks did not receive fat in their diet. Figure 2, on the same plate,

shows the feather development of a chick which had received 1/2 percent fat. The primary feathers in the 1/2 percent fat lot were decidedly better than the no fat lot. Plate II, Fig. 1 shows the primary wing feathers from a chick which had received oil at the rate of 1 percent of the diet. The feathering for this lot was superior to the feathering of both the no fat and 1/2 percent fat lots. Figure 2 of Plate II indicates the feathering when chicks received oil at the rate of 2 percent of the diet. Feathering in this lot was poorer than in the 1 percent fat lot. Plate III includes the primary wing feathers of chicks from the 4 percent fat lot (Fig. 1) and 10 percent fat lot (Fig. 2). Feather development for both lots was below that of the 1 percent fat lot. From these data it was concluded that fat in the diet of the chick should be near the 1 percent level.

The same type of chick down was noted in this experiment as in Experiment I. It was concluded that the chick's down in lots 1, 8 and 9 were definitely drier and more brittle than the other lots. In these same lots the same dry brittle condition was noted in the first feathers that appeared, but not as distinct. Lots 1, 8 and 9 were much slower in receiving their thigh feathers as compared to the other lots. Chicks in the other lots grew feathers comparable to the control of lot 10.

Characteristic of a fat deficiency in rats is a dermatitis which causes scales to appear on the skin of the tail. The rest of the body is also very dry. Since the lack of fat in the diet affects the rat in this way, the deficiency of fat in the chicken may cause similar results. It was noted that most

EXPLANATION OF PLATE I

Fig. 1. Experiment II, lot 1, primary wing feathers of a bird from the no fat lot. Note the poor feathering.

Fig. 2. Experiment II, lot 5, primary wing feathers of a bird from the 1/2 percent fat lot. Note the improved feathering over the no fat lot.

PLATE I

Fig. 1.

Fig. 2.

EXPLANATION OF PLATE II

Fig. 1. Experiment II, lot 6, primary wing feathers of a bird from the 1 percent fat lot. Note the improved feathering over the other two lots.

Fig. 2. Experiment II, lot 7, primary wing feathers of a bird from the 2 percent fat lot. Note the feathering which is not as good as the feathers in preceding lot.

PLATE II

Fig. 1.

Fig. 2.

EXPLANATION OF PLATE III

Fig. 1. Experiment II, lot 8, primary wing feathers of a bird from the 4 percent fat lot. Note the ragged appearance of the feathers.

Fig. 2. Experiment II, lot 9, primary wing feathers of a bird from the 10 percent fat lot.

PLATE III

Fig. 1.

Fig. 2.

feathers and down of chicks of lot 1, which were on the fat deficient diet, were very dry and brittle; this would be an indication of a dermatitis similar to that noted in rats.

The general appearance of the birds was similar in most lots. The control lot appeared to be in the best health of all the lots throughout the 28-day period. Chicks in lot 4 or the yeast diet were next. The poorest condition was in lot 9 (10 percent fat) where cannibalism was noticed. Even after the removal of 1/8 of an inch of the upper mandible the chicks still seemed to pick. Lot 8 had a mean weight of 133 g yet the extremes were from a low of 93 g to a high of 178 g or 85 g spread. The chicks that were lowest in weight, in most cases, were the chicks showing the poorest feathering and poorest general health. The heaviest chicks, for the most part, had the best health. One chick was noticed in lot 9 and it weighed only 79 g while the average was 137.2 g or 58.2 g from the mean. This chick showed the poorest feather development but was in good health throughout the experiment. Either the diet was lacking in some essential nutritive fraction or the 10 percent fat diet was too oily for the chick. Most of the other chicks in the pen showed poor feathering but their body weights were good as the highest had a weight of 176 g.

The general appearance of the birds of the different lots of Experiment II can be studied on Plates IV, V and VI. These plates indicate the amount of growth the different lots had at the end of 28 days. Plate IV, Fig. 1 shows the excellent growth

and good feathering that was accomplished when chicks were fed a good broiler ration. This was the non-purified diet lot. Figure 2 of Plate IV shows the slower growth and poorer feathering when chicks were fed a purified diet with no added fat. Figure 1 of Plate V shows the growth and feathering of a chick which had received oil at the rate of 1 percent of the diet. Growth and feathering of this lot were superior to that of the no fat lot. Also the growth and feathering of the 1 percent fat lot were superior to that found in the 2 percent fat lot (Plate V, Fig. 2). Plate VI, Fig. 1 shows the poorer growth of chicks from the 4 percent fat lot. This photograph also shows how slow the feathering was as compared to the control group. Figure 2 of Plate VI was a chick from the 10 percent fat lot. It indicates the slowness of feathering. Growth in this lot was much slower than the chicks of 1/2 percent and 1 percent fat lots.

Table 11. Experiment II, feed efficiency for Kansas White Rock chicks for 28 days.

Lots	7 days	14 days	21 days	28 days	Average
			grams		
1	3.53	6.06	2.52	4.26	4.04
2	3.48	5.33	1.63	3.98	3.605
3	4.96	4.71	2.02	3.04	3.68
4	2.648	3.58	1.56	4.07	2.964
5	4.66	6.03	1.18	4.78	4.16
6	3.88	7.07	2.16	3.17	4.07
7	2.76	6.59	1.62	4.11	3.77
8	2.51	5.49	2.20	3.75	3.487
9	2.69	5.59	2.93	4.39	3.90
10	4.34	3.31	3.01	1.76	3.105
Average	3.546	5.376	2.083	3.731	3.683

PLATE IV

Fig. 1. Experiment II, lot 10, note the good feathering for a chick of 28 days of age.

Fig. 2. Experiment II, lot 1, note the slow feathering and the ragged appearance of the feathers over all the chick.

PLATE IV

Fig. 1.

Fig. 2.

PLATE V

Fig. 1. Experiment II, lot 6, note the feathering which is better than the no fat lot yet not as good as the control.

Fig. 2. Experiment II, lot 7, note the feathering which was superior to the no fat lot.

PLATE V

Fig. 1.

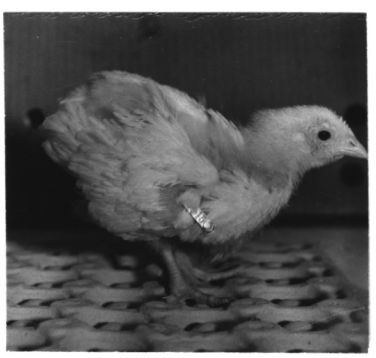

Fig. 2.

PLATE VI

Fig. 1. Experiment II, lot 8, the feathering which is not as good as the 1 percent fat group but better than the no fat group.

Fig. 2. Experiment II, lot 9, the feathering in this lot is very slow and about the same in appearance as the no fat lot.

PLATE VI

Fig. 1.

Fig. 2.

Feed Efficiency. Feed efficiency was checked in Experiment II and compared for the grams of gain in body weight per gram of feed consumed. This can be studied in Table 11. The weekly average feed consumed per gram of gain was included in addition to the average for the whole 28-day growth period. After studying Table 11, it can be noted that the amount of feed required for a gram of gain was very high the second week. The amount of feed consumed was very low for the third week. This fact may have been caused by the outbreak of Newcastle disease which hit the second week. The fourth week weight was about the same as the average of the 28-day experimental period. It should be stated that the amount of feed necessary for the first week's growth for the 10 groups was wide spread. It ranged from a low of 2.51 g to a high of 4.96 g or a 2.46 g spread. Part of this was due to feed wastage when the chicks were fed on egg flats. It was very difficult to retrieve any lost feed which had fallen into the droppings. When the egg flats were removed, feed wastage was minimized.

The control lot fed a regular broiler mash did not have the best feed efficiency. The control lot was second to lot 4. Lot 4 received the 5 percent yeast diet. The yeast diet had an average feed efficiency of 2.964 g of feed per gram of gain while the control lot had an average of 3.105 g of feed per gram of gain. Diet 8 which consisted of 4 percent fat was next in line with a 3.487 g average. The last place group for feed efficiency was lot 5 which received 1/2 percent fat. It was high with a

4.16 g average. It must be recognized that excellent growth for chicks on a high concentrated feed is between 2.5 to 3.0 g per gram of gain. This would tend to indicate that even when growth was slower on purified diets, the chicks still have good feed efficiency.

The no fat group, had next to the poorest feed effieicncy of all lots. This reveals that fat or oil in the ration was necessary in an excess of the 1/2 percent level.

As shown in Table 11, the data for feed efficiency were treated statistically by the F-test and was found to be non-significant.

Table 12. Experiment II, mortality of Kansas White Rock chicks for 28 days.

Lots	7 days	14 days	21 days	28 days	Percent of chicks started
1	0	0	2	1	30
2	0	0	0	0	00
3	0	1	0	0	10
4	0	1	0	1	20
5	0	1	1	2	40
6	0	0	1	1	20
7	0	1	1	1	30
8	0	0	3	0	30
9	0	0	3	2	50
10	0	1	1	0	20
Total	0	5	12	8	25

Mortality. Mortality in Experiment II was higher than anticipated because of the outbreak of disease in the second week. The third week's losses were 12 chicks and that was almost

half of all the losses incurred in the experiment. Referring to Table 12 it is indicated that the total mortality was 25 percent of the chicks started. The highest losses were found in lot 9 which received 10 percent corn oil. It was not known whether the 10 percent fat was toxic to the chicks or not. In Experiment I, mortality for a similar lot was 3. Chicks in lot 9 were very nervous and flighty after the first week. The highest week for mortality for this lot was the third week when 3 chicks were lot and 2 more were lost during the fourth week. After studying Table 12, it should be noted that lot 2, basal mixture plus APF but no fat, had no mortality during the entire experiment; while lot 3 had only 1 loss during the second week. Lot 5 which was the 1/2 percent fat diet had 4 losses while the no fat lot had 3 deaths. It should be noticed that during the third week the heaviest losses were incurred. This week was followed closely by the fourth week with 8 chick deaths. During the first 7 days of the experiment, no deaths were recorded.

Experiment III

Diets. The rations used in Experiment III were the same diets that were used in Experiment II. The only difference was that the no fat, 1/2 percent fat, 1 percent fat, 2 percent fat and 10 percent fat diets were used. The diets are listed in Table 5. These diets were fed to 5 chicks per lot and for a period of 21 days instead of 28 days as in the other two experiments.

Ultra-violet light was furnished to the chicks once a day for a period of 20 to 30 minutes. This light was used to supplement the vitamin D_3 found in the vitamin mixture. The vitamin mixture was given twice weekly in this experiment and administered as in the previous experiment. Chicks did not show any outward signs of fat-soluble vitamin deficiencies.

Table 13. Experiment III, growth for Kansas White Rock chicks for 21 days.

Lots	Beginning	7 days	14 days	21 days
		grams		
1 - No fat	42.0	55.5	76.2	103.4
2 - ½% fat	43.8	65.5	101.6	139.8
3 - 1% fat	41.5	59.6	88.4	132.8
4 - 2% fat	44.9	53.9	76.4	113.2
5 -10% fat	42.8	57.3	81.0	120.0

Growth, 21-Day Weights. Weight gains in Experiment III were very satisfactory. The chicks were not infected by an outbreak of any disease so good results were obtained. Growth curves are illustrated in Fig. 3 and growth weights in Table 13. Statistically, the growth weights of Experiment II were highly significant at the 5 percent and 1 percent levels when the F-test was used for the analysis as indicated in Table 14.

Table 14. Experiment III, analysis of variance of growth for Kansas White Rock chicks for 21 days.

Sources of variance	D/F	Mean of squares	Est. of variance
Between	4	4,303.8	1,075.95
Individual	20	3,393.6	169.68 **
Total	24	7,697.4	

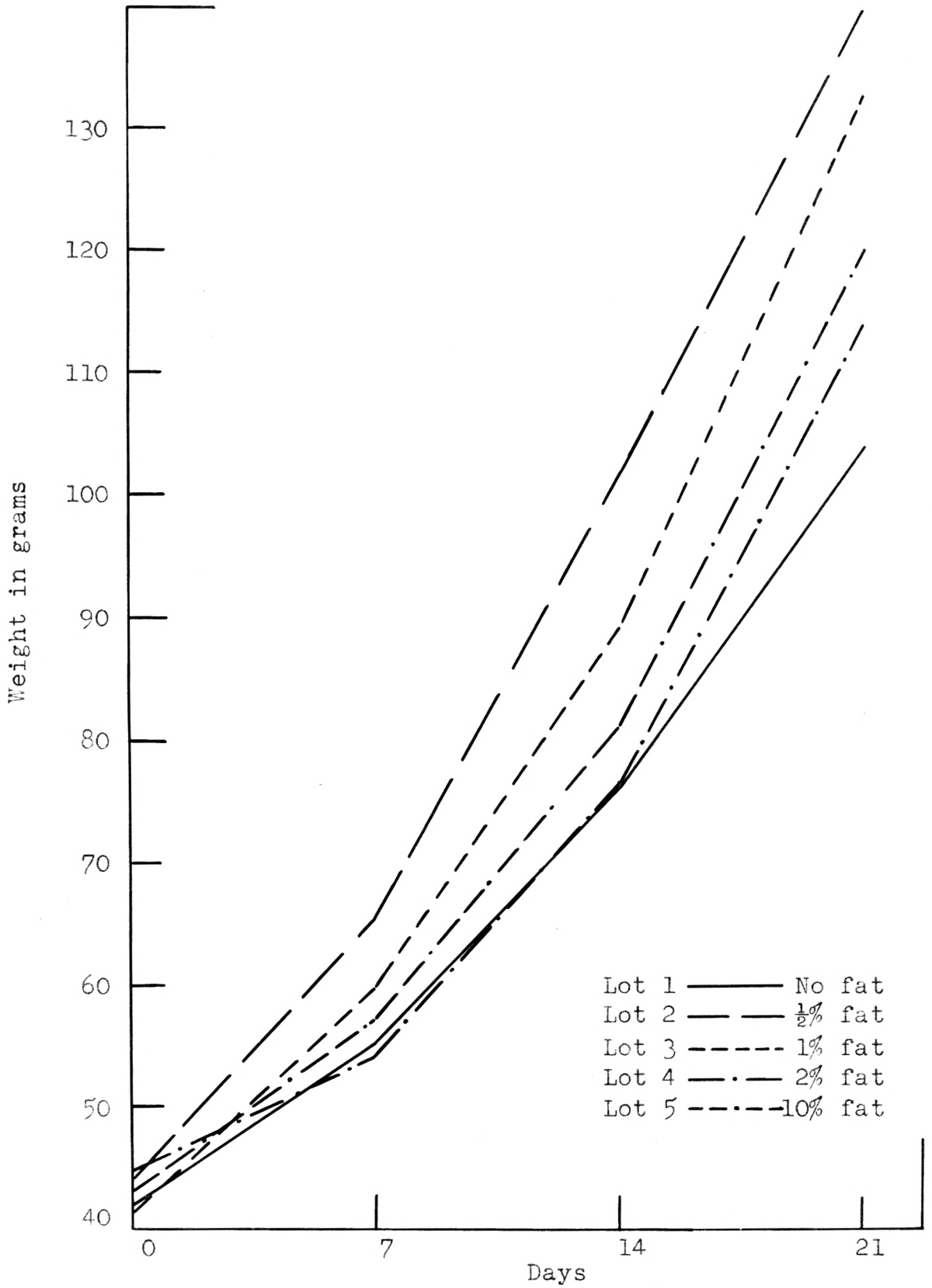

Fig. 3. Experiment III, growth for Kansas White Rock chicks for 21 days

Experiment III was a rerun of Experiment II. The results of the previous experiment, with the no fat diet verses the diets with different levels of fats, were used as a basis for this experiment.

Lot 1 chicks, on a no fat diet, weighed 103.4 g at 21 days as compared with 139.8 g for the chicks receiving ½% fat. This was a difference of 36.4 g. When compared statistically, it was found that the differences between the two lots were highly significant both at the 5 percent and 1 percent levels as shown in Table 15.

Table 15. Experiment III, t-test of growth for Kansas White Rock chicks for 21 days.

Diets compared	t-test
No fat and ½% fat	4.08 **
No fat and 1% fat	2.65 *
No fat and 2% fat	1.00
No fat and 10% fat	1.64

By all indications, it must be concluded that at least 1/2 percent of fat in a diet is necessary for normal growth. It was noted also when diets 1 and 3 were tested by the t-test that growth differences were significant at the 5 percent level. Lot 3 had a mean growth of 132.8 g for the 21 days while the no fat lot grew 29.4 g less in the same period of time.

Birds in lot 4 grew on the average of 113.2 g for 21 days. This was 9.18 g heavier than the first lot, yet the difference in weight was nonsignificant. The amount of growth for the 21

days, even when nonsignificant, would tend to leave the impression that fat was necessary for the extra growth. Lot 5 chicks receiving 10 percent corn oil weighed 120 g. This was over 16 g heavier than the no fat lot. When treated statistically, lots 1 and 5 were nonsignificant, yet nearly so, at the 5 percent level.

The indications of Experiment III point to the fact that fat or oil must be added at the rate of less than 4 percent; most likely the fat average should be between 1/2 percent to 1 percent of the diet.

Feathering and General Appearance. In Experiment III, the feathering and general appearance were appraised. It was concluded that the feathering and appearance were as good or better than in Experiment II. No indication of curling or frilling of the feathers was noticed as was the case in Experiment I. In all lots the chicks ate well throughout the experimental period. The feather growth and general health were excellent. Lots 1 and 5 were slower in receiving their thigh and breast feathers, but this was not too noticeable.

The general appearance and health of the chicks were very good. The chicks ate well throughout the 21-day period and no outward signs of disease or functional disorders were indicated. No perosis or other nutritional deficiency symptoms were encountered throughout the experimental period and growth was better than in Experiment II.

Table 16. Experiment III, feed efficiency for Kansas White Rock chicks for 21 days.

Lots	7 days	14 days	21 days	Average
		grams		
1 - No fat	5.25	3.42	2.71	3.79
2 - ½% fat	4.44	2.78	2.23	3.15
3 - 1% fat	4.39	2.95	2.04	3.126
4 - 2% fat	5.66	4.28	2.31	4.083
5 - 10% fat	5.48	4.54	3.32	4.448
Average	5.044	3.594	2.522	3.72

Feed Efficiency. Feed efficiency in Experiment III is summarized in Table 16. It should be noticed that the first 7 day's total average of feed was much higher than the other two periods. During the first 7 days it was 5.044 g of feed per gram of gain, while the last week it was 2.522 g. This was in part due to the feed wastage resulting from placing feed on egg flats during the first week. The average for the 21-day period was 3.72 g.

Lot 3, the chicks on the 1 percent fat diet, had the best feed efficiency for the 21-day period with an average of 3.126 g per gram of gain. The third week this group used only 2.04 g of feed for 1 g of gain. The 1/2 percent fat lot was second in feed efficiency, than the no fat lot followed by 2 percent and 10 percent fat lots.

Table 17. Experiment III, analysis of variance for feed efficiency for Kansas White Rock chicks for 21 days.

Sources of variance	D/F	Mean of squares	Est. of variance
Between	4	5.0358	1.25895
Individual	10	16.9740	1.69740
Total	14	22.0098	

When the 5 lots were tested by the analysis of variance, there was a nonsignificant difference between the lots as indicated in Table 17. It should be remembered that only a few chicks were used in this experiment so the 5 percent level was rather wide.

Feed efficiency for this experiment was very good. Chicks fed a high density diet require from 2.5 to 3.0 g of feed per gram of gain. The average for the 5 lots was 3.72 g of feed per gram of gain. Even though there was no difference between the groups statistically, it was concluded that fat was necessary for good feed efficiency. Experiment II also showed nonsignificant difference in feed efficiency among the 10 lots.

Mortality. No chicks were lost throughout the 21-day growth period in any of the lots. Growth weights followed a definite pattern in all lots.

DISCUSSION

Kansas White Rock chicks were used in all three experiments. In Experiment I, 100 straight-run chicks were started and placed

in 10 lots with 10 chicks each. Experiment II used the same number of straight-run chicks and they were divided into 10 equal lots. In Experiment III, 25 sexed pedigreed cockerels were used and divided into 5 lots.

From the preliminary experiment, helpful knowledge was gained about the use of synthetic diets as feed for chicks. It was noted that proper growth was lacking in all lots of Experiment I because of the lack of certain nutrients. In the other two experiments, these conditions were remedied. More growth promoting vitamins and amino acids were added to the diets in addition to the correction of vitamin D deficiency and the calcium-phorphorus balance.

Chicks in Experiment I, given high amounts of fat or oil in the form of corn oil or linseed oil, did not grow properly. Linseed oil seemed to stunt the growth of the chicks. Growth was poor in the first experiment, and thus it was hard to draw any conclusions.

Experiment II indicated some very good results for the 28-day feeding period. Growth for this test is shown in Table 8 and Fig. 2. The growth differences were statistically significant when analyzed by the F-test.

Ultra-violet light was given to the chicks in Experiment II. This controlled the vitamin D deficiency symptoms which had appeared in the preliminary experiment. The amount of calcium-carbonate in the basal mixture was doubled to make the mixture conform with the recommendation of the National Research Council

for the percentage of calcium-phosphorus in a ration. Copper sulfate and cobalt sulfate were increased at the rate of 16 g per 100 pounds of feed. These two compounds were added to protect against the development of an anemic condition.

Arginine, the amino acid related to rapid growth, was included in the diets for Experiments II and III. This compound was added at the rate of 98 g per 100 pounds of feed. Gelatin was added also to supply large amounts of some of the other amino acids. It was supplied at the rate of 1 pound per 100 pounds of feed.

For Experiments II and III, the known growth promoting vitamins were doubled from the amounts used in Experiment I. Riboflavin was increased to 800 mg per 100 pounds of feed while the National Research Council recommendation calls for only 160 mg. Folic acid was increased to 72.8 mg per 100 pounds of feed. The recommended allowances stated by Titus (1949) for folic acid was 25 mg per 100 pounds. Crystalline biotin was also added to the diets in the last two experiments. The recommended allowances by the National Research Council for biotin is 4.5 mg per 100 pounds of feed and enough crystalline biotin was included in the diets to make 4.54 mg. "Vitab" which was supplied in all three experiments carried some biotin. Pantothenic acid was increased from 346 mg to 668 mg per 100 pounds of feed.

Lots for Experiment II were divided as to no fat, no fat plus APF, no fat plus 2 percent defatted liver extract, no fat

plus 5 percent brewer's dried yeast, 1/2 percent fat, 1 percent fat, 2 percent fat and 10 percent fat. One lot was the control which received a regular broiler diet.

Growths of the various lots were analyzed statistically. A significant difference was indicated at both the 5 percent and 1 percent levels when the 28-day weights were compared.

Feathering in Experiment II was far superior to that found in the preliminary test, but the feathering was not as good as would be expected. The chick-down in the no fat lot appeared to be very dry and brittle. Furthermore, this lot did not receive their thigh feathers as rapidly as the other lots. The skin of the birds in this lot appeared and felt very dry, yet no scales or dermatitis was apparent.

The general health and appearance of the chicks in this trial were very good. An outbreak of Newcastle disease was encountered the second week of the growth period and the disease resulted in heavy mortality.

Experiment III was started to duplicate results received in the previous experiment. Five lots were used to verify the results obtained during Experiment II for the no fat, 1/2 percent, 1 percent, 2 percent and 10 percent fat groups. The experiment was conducted for 21 days instead of 28 days. Excellent growth was received by all lots. The 1/2 percent fat lot led the other 4 lots as to growth, followed closely by the 1 percent fat lot. Indications point to the need of fat in the growing chick's ration.

SUMMARY

Experiment I, growth was poor and mortality heavy. The lack of growth was caused by an inadequate diet so no conclusions were drawn from the results obtained.

Experiment II, growth was good but the chicks were slowed down during the second week because of an outbreak of Newcastle disease. Results were used and much valuable information was gained.

Experiment III, the birds grew normally and the results were excellent except that a small number of chicks were used and this affected the significance of the results.

Observations made during the experimental period and the conclusions are as follows:

1. Chicks require fat in the growing ration.

2. Chicks raised on synthetic diets used in these experiments require less than 4 percent fat for best growth probably 1/2 percent to 1 percent being adequate.

3. Significant difference was found to be present in the last two experiments when purified diets were compared by the use of the analysis of variance for growth.

4. The incorporation of liver and yeast into the synthetic diets in Experiment II improved growth.

5. Slow feathering and ragged, rough plumage were noticed in the no fat group when birds of the broiler ration group were used as a criterion.

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