200000 units of i. m. penicillin G gave higher and earlier peak levels but these were less sustained than from oral penicillin V; the average number of dilution-hours, however, was quite similar for these 2 forms at this level, and these were both greater than from oral penicillin G. After doses of 400000 units and 1000000 units, on the other hand, i. m. penicillin G gave the highest and best sustained levels and oral penicillin V gave higher and better sustained levels than oral penicillin G; these differences are reflected in the number of dilution hours of penicillin in the plasma.

Summary. Oral penicillin V gave higher and better sustained levels of penicillin activity in the plasma than oral buffered potassium penicillin G at each of 3 dosage levels, *viz.* 200000, 400000 and 1 million units. Intramuscular penicillin G yielded higher and better sustained levels than oral penicillin V in equivalent doses given at levels of 400000 or 1 million units. An i. m. dose of 200000 units of penicillin G produced higher peak levels and these occurred earlier but they were less well sustained than with this amount of oral penicillin V; the total amount of penicillin absorbed from this amount of penicillin was not significantly different for these 2 dosage forms. Persons over 60 years of age attained peak levels later; in general they had higher and better sustained levels of penicillin in the plasma from any given dose than did younger individuals.

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Effect of Dietary Protein and Energy on Chick Liver Fat Accumulation.*† (22138)

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Best and Huntsman(1) discovered that a dietary deficiency of choline resulted in an excessive accumulation of fat in rat livers. Later work, Harper *et al.*(2) indicated that such compounds as glycine, serine, methionine and betaine, which may function as choline precursors, are able to reduce the level of liver fat in rats on choline-free diets. Channon and Wilkinson(3) and Best and Huntsman(4) suggested that the deposition of liver fat might

TABLE I. Basal Diet for Preliminary Period.

Ingredient	%
Glucose	54.4
Soy protein*	31.6
Soybean oil	4.0
Cellulose	3.0
Methionine	.5
Mineral mix†	5.5
Vit.-antibiotic mix‡	1.0
Total	100.0

* Drackett Assay Protein C-1.

† Provides per lb diet: NaCl 0.5%, Ca 1.6%, P 0.88%, K 1.3 g, Zn 1.08 mg, Mn 33.3 mg, Fe 30.6 mg, Co 0.6 mg, Cu 1.2 mg, Mg 300 mg, and I 5.0 mg.

‡ Provides per lb diet: Vit. A 4000 I.U., Vit. D_3 500 I.C.U., alpha-tocopherol 7.0 mg, menadione 0.6 mg, choline Cl 868 mg, inositol 455 mg, niacin 45 mg, calcium pantothenate 10 mg, riboflavin 3.6 mg, pyridoxine-HCl 2.7 mg, thianine-HCl 1.8 mg, folic acid 1.4 mg, p-amino benzoic acid 0.9 mg, biotin 90 μg, vit. B_{12} 6 μg, penicillin 4 mg.

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TABLE II. Experimental Diets.

Ingredient	Calculated dietary protein level									
	14	18	22	26	30	14	18	22	26	30
	Low energy*					High energy†				
Glucose	52.3	47.6	42.9	38.3	33.5	66.6	61.6	56.4	51.4	46.2
Soy protein	16.4	21.2	26.1	30.9	35.8	16.4	21.2	26.1	30.9	35.8
Soybean oil	1.0	1.0	1.0	1.0	1.0	10.0	10.2	10.5	10.7	11.0
Cellulose	23.3	23.2	23.0	22.8	22.7	—	—	—	—	—
Methionine	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
Mineral mix‡	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Vit.-antibiotic mix§	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Calculated to contain 720 C/lb productive energy.
† " " " 1055 C/lb " " .
‡ Minerals supplied as in Table I.
§ Vitamins and antibiotic supplied as in Table I.

be linked to protein metabolism. In this respect Eckstein(5) found that only methionine exhibited a lipotropic effect when each of the 10 essential amino acids was incorporated singly into a choline-free diet. Threonine(6) has been shown to exhibit a lipotropic effect when incorporated into a casein diet complete in all known nutrients, but this phenomenon may have occurred because of the low biological availability of threonine in casein(7). The data of Winje *et al.*(8) support this conception. Recently Lucas and Ridout(9) substantiated the suggestion of Harper *et al.*(2) that the level of protein in the diet has an influence on the accumulation of fat in the livers of rats. They reported a larger percentage of fat in the livers of rats on methionine-supplemented low-protein diets than in the livers of rats on diets higher in protein. As far as the authors are aware, no such effect on liver fat has previously been reported for the chick.

The purpose of this investigation was to study the effect of dietary protein and energy levels on the accumulation of fat in the livers of chicks.

Methods and materials. Eighty day-old chicks were maintained on a nutritionally complete basal diet (Table I) for 10 days after which they were randomly assigned to 40 pens containing 2 birds per pen. At this time 4 pens were allotted to each of the 10 experimental diets (Table II) under a restricted randomized block design. The experimental feed, except that which was in the feeders, was kept refrigerated at 38°F during the experimental period. The birds were maintained in thermostatically controlled batteries with feed and water supplied *ad libitum* during the experimental period. After 10 days on the experimental diet the birds were sacrificed and their livers were removed and frozen at –20°F. The livers from the birds in each pen were pooled, washed of adhering blood and fatty tissue and blended in a Waring Blendor. The resulting homogenous mixture was dried for 16 hours at 212°F and then ground for analysis. Crude fat determinations were made according to the A.O.A.C.(10) method.

Results. The data in Table III indicate that the energy level of the diet apparently had no marked effect on the chick liver fat. A statistical analysis of the data indicates a significant linear response and a significant quadratic response in percent liver fat due to dietary protein level changes on the high energy diets and the low energy diets, respectively. As shown in Fig. 1, this suggests that the amount of fat in the liver is inversely related to the protein level of the diet.

Discussion. Chicks consuming a high fat (10%) diet accumulated no more fat in their

TABLE III. Effect of Energy Level of Diet on Response to Protein Level Increments.

Level of protein in diet (%)	Liver fat (%) High energy diet (1055 cal/lb)	Liver fat (%) Low energy diet (720 cal/lb)
14	13.35	12.35
18	13.76	13.58
22	11.25	13.24
26	10.57	11.79
30	10.20	10.54

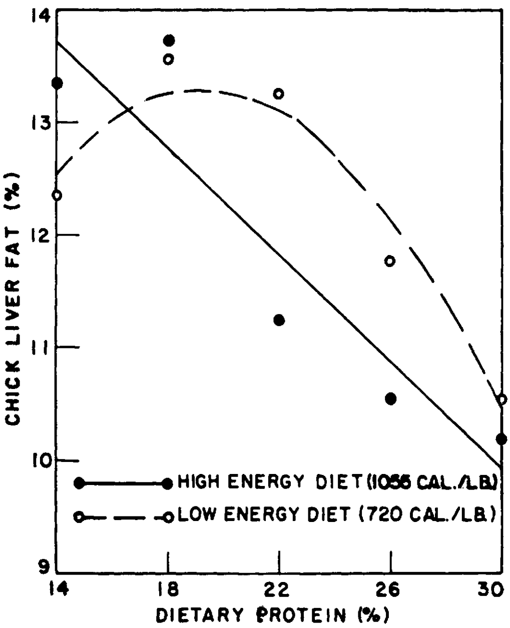

FIG. 1. Effect of high and low energy diets on liver fat content with relation to protein level increments.

livers than those consuming a low fat (1%) diet. This indicates that dietary fat *per se* was not deposited in the chick's liver to any great extent. Harper *et al.*(2) reported a similar effect in rats.

The present work reveals that over a specific (14 to 30%) range there is an inverse relationship between the level of protein in the diet and the amount of fat deposited in the chick's liver. These results are in agreement with those of Lucas and Ridout(9) with rats. The diets in the present study were sufficient in all nutrients known to be required by the chicks, and these, as well as the energy content of the diet, were held approximately constant over the range of dietary protein levels tested. In most of the previous work using the rat, these extraneous variables had not been as closely controlled.

It is apparent from these data that protein exerts a lipotropic effect not directly involving its choline or choline precursor content.

Summary. The present work reveals that over a range of protein levels from 14 to 30% there is an inverse relationship between the level of protein in the diet and the amount of fat deposited in the chick's liver. The dietary energy level does not appear to influence the chick liver fat level.

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