THE EFFECT OF DIETARY ENERGY ON THE PROTEIN REQUIREMENTS OF GROWING TURKEYS

By

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INTRODUCTION

The margin between production cost and live weight market price of turkeys is becoming progressively smaller. The average price received for live market turkeys declined from 34 cents a pound in 1953 to 23 cents a pound in 1957. If the live weight market price continues to follow this downward trend, production costs will have to be reduced in order to maintain a workable profit margin for the producer. A reduction in production costs below the point required to maintain a narrow profit margin could bring about a reduction in the retail price to the consumer. A reduction in the retail price could result in an increase in the annual consumption of turkey meat above the present 5.6 pounds per capita. Such an increase in consumption would diminish the surplus in storage and might even increase turkey production.

Feed cost constitutes approximately seventy percent of the total production cost of market turkeys. A reduction in feed cost can best be obtained by increasing the efficiency with which the feed is utilized. In order to obtain a more efficient ration, the research worker must first obtain additional basic knowledge on the nutrient levels and their interrelationships for growing turkeys. This must be done if turkeys are to be grown at the maximum rate allowed by present genetic potentials.

This study was conducted in order to obtain basic information about the dietary energy and the protein requirements of growing turkeys through the first eight weeks of the growing period. This basic information will be useful in the formulation of more efficient practical starter rations.

REVIEW OF LITERATURE

Effect of Dietary Energy on Protein Utilization

The efficiency of nutrient utilization depends upon the proper balance of all nutrients in the diet. Hoagland and Snider (1941) obtained maximum growth with diets which contained 30 percent of added fat. The diets were utilized with approximately equal efficiency whether they contained 15, 30 or 54 percent of added fat. Forbes *et al.* (1946) found that digestibility and the retention of food nitrogen were highest with diets which contained 30 percent of added fat. A higher energy intake was found to improve the utilization of dietary protein, Forbes and Yohe (1955).

Dietary energy level is closely related to efficiency of feed utilization. Scott *et al.* (1947) demonstrated that chick rations high in energy promoted more rapid growth and better feed conversion than did rations of lower energy content. Scott, Heuser and Norris (1948) found that more rapid poult growth and more efficient feed conversion could be obtained when the unidentified vitamin content and the energy level of the ration were increased as the protein level was increased.

Hill and Dansky (1950) found that chick growth was reduced when a high energy and low protein ration was fed, but that growth was restored when the energy level was lowered. Sunde (1956) reported that a ration high in protein and low in energy reduced growth and efficiency of feed utilization. The addition of energy to this ration improved both growth and efficiency of conversion. Hill and Dansky (1954) concluded that feed consumption was determined primarily by the energy level of the diet.

Biely and March (1954) indicated that the addition of energy, in the form of added fat, may be advantageous in both chick and poult rations when relatively high levels of protein are fed.

Studies by Sielder and Schweigert (1953); Sunde (1954a) and Runnels (1955) indicated that the use of animal fat in broiler rations improved feed conversion. Sunde (1954b) and Carver et al. (1954) reported that hydrogenated fat and stearic acid would not improve feed utilization. Biely and March (1954) reported that animal tallow gave the most consistent improvement in growth rate.

Energy-Protein Relationship

The recent availability of stabilized fats and greases for use in poultry feeds has permitted rations with higher energy levels to be formulated. Combs and Romoser (1955); Leong et al. (1955); Donaldson et al. (1955) and Donaldson et al. (1956) initiated studies on the relationship between energy and the protein level in broiler rations. These research workers established that a Calorie-protein ratio of 42:1 in terms of productive energy appeared to be adequate for optimum broiler growth. The optimum energy-protein ratio was found to change at each protein level, Sunde (1956).

Hill and Dansky (1954) conducted studies to determine the minimum dietary energy level required by the chick for maximum early growth. The diets were formulated to contain a constant protein level of 20 percent with energy levels that ranged from 505 to 975 Calories of productive energy per pound of diet. This range of energy levels was obtained by substituting pulverized oat hulls for the energy components of the diet at levels up to 40 percent of the diet. Under these conditions, maximum growth rate was obtained consistently with a ration which contained an energy level of 623 Calories per pound. The same growth rate was also obtained at a lower energy level with an increase in feed consumption.

Dymsza _et al_. (1953) reported that the energy requirement for the growing poult to ten weeks of age was between 460 and 875 Calories of productive energy per pound of ration. Energy was utilized more efficiently when the ration contained 20 percent of fiber. It was reported by Dymsza _et al_. (1955a) that the diet which contained 744 Calories of productive energy per pound of ration produced the heaviest poults of both sexes. The ability of poults to make reasonable body weight gains on the lower energy diets was attributed to their ability to adjust feed intake within certain density limits.

Lockhart and Thayer (1955) fed poults a series of rations which contained different combinations of energy and protein. The best growth was obtained with a 30 percent protein diet which contained 880 Calories of metabolizable energy per pound of diet. Ferguson _et al_. (1956) reported that poults fed a diet which contained 24.8 percent of protein and 744 Calories of productive energy per pound of ration produced the best growth. This indicated that a Calorie-protein ratio between 25 and 31:1, in terms of productive energy, was required for optimum protein utilization by the growing poult. This is a much lower Calorie-protein ratio than is required by the growing chicken. Ferguson _et al_. (1957) reported that poults grew at a maximum rate when they were fed a diet which contained 28 percent of protein with an energy level of 914 Calories of productive energy per pound. Efficiency of feed conversion continued to improve at each protein level as the energy level was increased. Donaldson et al. (1957) also demonstrated this fact with chicks in an experiment in which different rations were fed which contained fat levels as high as 30 percent. These rations supported more rapid growth than was obtained with rations which contained lower fat levels. Less feed was required per unit of gain when fat was added, since the high fat rations contained relatively more nutrients per pound.

Amino Acid Requirements

It has been demonstrated that amino acid requirements vary directly with the protein intake, Almquist (1952). For most efficient protein utilization, each essential amino acid must remain in balance with the dietary protein level and with each of the other amino acids. Scott (1953) reported that the amino acid values which were obtained in the early requirement studies were based upon rations in which purified protein concentrates, instead of practical protein concentrates, were used. This worker concluded that natural proteins furnish smaller amounts of available amino acids per unit of protein than do hydrolysed proteins. Almquist (1947) reported that chicks gained faster on diets in which the amino acids were supplied in the form of natural proteins than did chicks fed diets supplemented with synthetic amino acids or hydrolysed proteins. The maximal requirements determined with these two kinds of protein are in good agreement.

Arginine: Kratzer et al. (1947) fed poults a purified diet which contained 25 percent of protein and a series of graded levels of arginine. Maximum growth was obtained at an arginine level of 1.35 percent. Fisher et al. (1956a) reported that the arginine requirement of the chick, when measured by growth and efficiency of feed utilization during the first three weeks of life, was greater than 1.3 percent. This research work indicated that the arginine requirement might be as high as 1.9 percent. Both growth and feed conversion exhibited a unique plateau as arginine supplementation was increased up to 1.9 percent. Savage and O'Dell (1956b) concluded that as the arginine content of the ration was increased to levels that produced maximum growth, the magnitude of the response to added glycine was diminished.

Glycine: Kratzer and Williams (1948) fed poults a purified diet which contained 24 percent of protein. This purified diet was microbiologically assayed and found to contain 0.12 percent of glycine. This diet had to be supplemented with 0.75 percent of additional glycine in order to produce maximum growth. The glycine requirement for poults when a 24 percent protein diet was fed appeared to be between 0.87 and 0.90 percent. Monson et al. (1955) noted a marked growth response from a sucrose diet which was supplemented with 1.5 percent of glycine when a mixture of bacitracin and penicillin was added.

Fisher et al. (1955) fed diets which contained sub-requirement levels of niacin and vitamin B_{12}. These diets contained 1.5 percent of glycine. It was concluded from the data which were obtained that the glycine requirement for optimum growth and feed conversion was in excess of 1.5 percent, both in purified and practical starting rations. Savage et al. (1955a) concluded that when a diet contained 1.5 percent of supplemental arginine, satisfactory growth could be obtained on levels of glycine much lower than current recommendations.

Isoleucine: Kratzer et al. (1952) fed poults a semi-purified diet which contained blood meal and gelatin and was supplemented with cystine and methionine. This diet contained 0.3 percent of L-isoleucine. Maximum poult growth was obtained when this diet was supplemented with 0.5 percent of L-isoleucine. These research workers estimated that the requirement of poults for L-isoleucine was 0.8 percent.

Lysine: Grau et al. (1946) fed semi-purified diets which contained 20 and 24 percent of protein. These diets were analysed and found to contain 0.56 and 0.67 percent of lysine, respectively. The total amount of dietary lysine which was required to support maximum growth was 1.3 percent in the 24 percent protein diet. It was pointed out by Grau (1948) that the lysine requirement must be identified as to protein level. Fritz et al. (1946) fed practical diets which contained 24 and 25 percent of protein. These diets were calculated to contain between 1.1 and 1.2 percent of lysine. These levels were adequate for normal growth and normal feathering. German et al. (1949) fed a practical diet which contained 22.4 percent of protein. This diet was microbiologically assayed and found to contain 0.82 percent of lysine. The addition of 0.48 percent of L-lysine supported normal growth and feather pigmentation. Kratzer et al. (1950b) stated that the level which was necessary for the prevention of white barring was closely related to the protein content of the diet. This level was slightly less than the amount required for maximum growth.

Kratzer (1950a) reported research studies in which a comparison was made of the biological activity of D- and L-lysine for poults. It was observed that the poult cannot utilize the D-isomer either for normal growth or for the prevention of white barring in feathers. Baldini et al. (1954) reported that lysine was the first limiting amino acid in a 20 percent corn-soya diet. Klain et al. (1954) reported that the addition of lysine to the diet of growing poults increased growth at the 21.8 percent protein level, but not at the 25.5 percent protein level.

Methionine: Kratzer et al. (1949) fed a diet which contained 24 percent of protein. This protein level was obtained with the use of an isolated soybean protein and two percent of condensed fish solubles. The diet was calculated to contain 0.37 percent of methionine and 0.05 percent of cystine. The optimum amounts of methionine and cystine for maximum growth were approximately 0.5 and 0.3 percent, respectively. Studies by Saxena and McGinnis (1952) failed to indicate an improvement in efficiency of feed utilization when methionine was added to the diet. Later studies by Atkinson et al. (1957); Pepper and Slinger (1955) and Donovan et al. (1955) indicated an increase in both growth rate and efficiency of feed conversion when the diet was supplemented with methionine.

Baldini (1955) found that the methionine requirement of the chick is related to the energy content of the diet and should be determined on an energy basis. The same result was also obtained with the poult by Ferguson et al. (1957), who reported that the growth response to methionine was greater in the presence of increased energy levels.

Tryptophan: Bird (1950) fed a diet which contained 38 percent of protein. The growth responses to DL-tryptophan as compared to L-tryptophan indicated that only 38 percent of the D-form was utilized by the poult. An addition of 0.21 percent of the DL-form or 0.15 percent of the L-form was required for maximum growth. This represents a total of 0.28 percent of L-tryptophan which is required in the 38 percent protein diet. Kratzer et al. (1951) concluded from these findings that the L-tryptophan requirement of the poult for maximum growth was approximately 0.92 percent of the dietary protein.

Effect of Fibrous Bulk on Energy and Protein Utilization

The effect of fibrous bulk on energy and protein utilization has been studied by different research workers. Panda and Combs (1950) reported that the crude fiber level depressed growth only when the productive energy level of the diet was decreased. Peterson et al. (1952) noted that chicks increased their rate of gain when fed a high energy diet which contained high quality protein and celluflour (cellulose). These data indicated that rate of gain was a characteristic of protein level. Anderson and Hill (1954) reported an increased growth rate when oat hulls at levels up to 30 percent were added to a high energy chick diet. Blaylock et al. (1954) conducted an experiment to determine the fiber level which would support the most efficient feed conversion. The ration which produced the maximum growth response contained 2.5 percent of fiber with 963 Calories of productive energy per pound of ration. Fisher and Weiss (1956b) concluded that fiber would stimulate feed consumption. The efficiency of feed utilization is not necessarily sacrificed, but may actually be improved when fiber is added to high energy diets. Mraz et al. (1956) indicated that the energy-volume ratio may be a better criterion of the growth promoting quality of the diet than other characteristics such as density, productive energy-weight ratio or fiber content.

Effect of Antibiotics on Protein Utilization

It was reported by McGinnis et al. (1951) that the antibiotics aureomycin, penicillin, streptomycin and terramycin stimulated the growth rate of poults fed a practical diet. Machlin et al. (1952) reported that the protein requirement for early growth of chicks was decreased by the addition of aureomycin to the diet. Aureomycin increased efficiency of feed utilization when it was added to a corn-soybean diet which contained vitamin B_{12}. The effect of the aureomycin was more pronounced with increased protein levels. Slinger et al. (1952) reported that a diet which contained penicillin produced little or no growth response when fed to male turkey poults. Penicillin supplementation of the same diet caused a marked response with female poults. Differences in the nutritive requirements of the two sexes are suggested as the basis for this difference in response. Slinger and Pepper (1954b) reported that penicillin may support greater growth with increased feed conversion by promoting increased feed consumption. Almquist (1952) indicated that the antibiotics might suppress some intestinal microorganisms that are destructive to protein and essential amino acids, or they may facilitate more efficient absorption of amino acids.

Interrelationship of Amino Acids and Vitamins

Choline: Kummerow et al. (1949) reported that the addition of high levels of fat to the diet increased the requirement of the chick for choline. Siedler and Schweigert (1953) observed no gain from choline supplementation of diets containing from two to eight percent of added fat. The choline requirement is not always raised by an increase in the dietary fat level. This was explained by an interrelationship among choline, folic acid, vitamin B_{12} and methionine. March and Biely (1956a) concluded that a diet which contained 600 milligrams of choline per pound, from natural ingredients, supplied sufficient choline for growth if the diet was adequate in methionine. The choline requirement of the chick is increased when high levels of fat are added to a diet low in methionine. However, the increase in choline requirement appears to be secondary to an increased need for methionine.

Folic Acid: March and Biely (1955) demonstrated that the response of chicks to folic acid was modified by the level of fat in the diet. There were no indications that folic acid aided fat absorption or had a lipotropic effect. March and Biely (1956b) concluded that the folic acid requirement of the chick was increased when high-protein high-fat diets were used.

Niacin: West et al. (1952) reported that excess niacin did not compensate for a tryptophan deficiency. Conversely, excess tryptophan did not compensate for a niacin deficiency. Childs et al. (1952) found that an excess of tryptophan could spare niacin to a slight extent, but could not fully compensate for a partial niacin deficiency. Later research demonstrated that L-tryptophan could completely replace niacin, but that niacin does not spare tryptophan, Fisher et al. (1954).

EXPERIMENTAL PROCEDURE

Six feeding trials were conducted between February 16 and November 21, 1956, in which approximately 1,400 straight-run poults were used. White Holland poults hatched from eggs laid by breeder flocks at Oklahoma State University were used in Trials I, II, III, IV and V. Broad Breasted Bronze poults hatched from eggs purchased from the Ralston Purina Research Farm were used in Trial VI.

A 28-day growing period was used for Trials I and V. Trial III was conducted during a 21-day growing period. Trials II, IV and VI were conducted during a 56-day growing period.

Trials I, III and V were conducted in conventional battery brooders with raised wire floors. Temperature and ventilation in the battery room were manually controlled. Trials II, IV and VI were conducted in floor pens which had dimensions of 6 x 12 feet. Each pen in one brooder house was equipped with a radiant-type gas brooder, a waterer, two feeders and a litter-covered concrete floor. One replicate of Trial VI was run in another brooder house which was equipped with a continuous brooding system, a waterer, two feeders and a litter-covered wooden floor. Day and night lights were used throughout each trial.

A completely randomized experimental design was used for each feeding trial. Using a set of random numbers, each replication of the experimental rations was given a battery pen number. Poults were selected for health and vigor and randomized into box sections which represented battery pens. Poults were randomized into the sections by placing one poult in each section during a continuous cycle. The cycle procedure was repeated until the desired number of poults was distributed into the respective lots.

Day-old poults were individually wing banded and weighed. The initial poult weights were recorded at the beginning of each feeding trial. Individual body weights and feed consumption by lots were recorded at weekly intervals during each feeding trial. These weights were obtained using gram scales. At the completion of each trial, the poults were sacrificed, and a post mortem examination was made to determine sex.

Feed and water were provided ad libitum. As the poults were placed in the brooders, poult size grit which had been colored with green food coloring was placed on the top of the feed to attract the poults. Grit was fed at weekly intervals throughout the remainder of each experiment.

The basal rations for each feeding trial (Table I) were calculated to contain 23 percent of protein with a Calorie-protein ratio of 40:1 in terms of metabolizable energy. Twenty-six rations were formulated from these basal rations plus different combinations of dried whole egg solids, stabilized animal tallow, glucose (Cerelose) or corn starch, pulverized oats and finely ground oat hulls. These rations (Table III) contained protein levels of 26, 28, 30, 32, 33, 34 and 36 percent. Calorie-protein ratios of 42, 46, 48, 50, 52, 55, 56 and 58:1 in terms of metabolizable energy were used in the various trials. The graded protein levels were obtained by varying the amounts of dried whole egg solids from 10 to 25 percent of the ration. Biotin was added at levels of three, six and nine milligrams per pound in each of the finished rations which contained dried whole egg solids at levels of 10, 20 and 25 percent, respectively.

TABLE I

COMPOSITION OF BASAL RATIONS

Trials	I	I	I	II	III	IV	V	VI
Ingredients	Parts of total ration							
Drackett (Basal I)[1]	15.0							
Feather meal (Basal II)[2]		22.5						
Casein (Basal III)[3]			15.0	15.0	15.0	15.0	15.0	15.0
Menhaden fish meal (60% protein)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Dehydrated alfalfa meal (17% protein)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
Dehydrated alfalfa meal (25% protein)								2.0
Dried brewers yeast	3.0	3.0	3.0	3.0	3.0			
Live yeast culture						3.0	3.0	3.0
Dried whey	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Dried condensed fish solubles	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Dried butyl solubles	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Vitamin concentrate[4]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Dicalcium phosphate (20% phosphorus)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Calcium carbonate	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Salt (NaCl)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Trace mineral mix[5]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
DL-Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
NF-180[6]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Pen-bac X[7]	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Vigofac[8]	0.25	0.25	0.25	0.25	0.25			
Fermacto[9]						0.75	0.75	0.75
Lecithin[10]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Cerelose (glucose)	7.50	7.50	7.50	7.50				
Stabilized animal tallow	10.0	10.0	10.0	10.0	2.0	2.0	2.0	10.0
Pulverized oats	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Totals	71.55	79.05	71.55	71.55	56.05	56.55	56.55	64.55

FOOTNOTES

1. Drackett--Assay C-1 protein. Archer-Daniels Midland, Kansas City, Missouri.

2. Feather meal--Marco Chemical Company. Fort Worth, Texas.

3. Casein--Hy-Case, a salt-free product. Sheffield Chemical Company, Incorporated, Norwich, New York.

4. Vitamin concentrate--refer to Table II.

5. Trace mineral mix--adds per pound of finished ration: manganese 27.5 mgms., iodine 0.88 mgms., cobalt 0.59 mgms., iron 8.3 mgms., copper 1.65 mgms., and zinc 1.52 mgms. Calcium Carbonate Company, Carthage, Missouri.

6. NF-180--furazolidone (N-(5-nitro-2-furfurylidene)-3-amino-2-oxazolidone). Dr. Hess and Clark, Incorporated, Ashland, Ohio.

7. Pen-bac X--contains per pound the equivalent of not less than five grams of bacitracin and one gram of 1-ephenamine penicillin G. Commercial Solvents Corporation, New York, New York.

8. Vigofac--a fermentation source of unidentified growth factors. Chas. Pfizer and Company, Incorporated, Terre Haute, Indiana.

9. Fermacto--this product replaced Vigofac in Trials IV, V and VI. A dried extracted streptomyces fermentation residue. Borden Company, Feed Supplements Department, New York 17, New York.

10. Lecithin--Alcolec S lecithin. American Lecithin Company, Incorporated, New York, New York.

TABLE II

COMPOSITION OF VITAMIN PREMIX

Ingredients	Adds per pound of finished ration
Vitamin A (10,000 I.U. per gm.)	6,000 I.U.
Vitamin D_3 (Delsterol 3,000 I.C.U. per gm.)	1,800 I.C.U.
Vitamin E (alpha-tocopherol-acetate 20,000 I.U. per gm.)	3,200 I.U.
Vitamin K_3 (Menadione)	5 milligrams
Riboflavin	4 milligrams
Calcium pantothenate	1.6 milligrams
Niacin	35.0 milligrams
Choline chloride (25% dry mixture)	600 milligrams
Folic acid	1.6 milligrams
Pyridioxine hydrochloride	2.6 milligrams
Thiamin hydrochloride	1.6 milligrams
Inositol	227 milligrams
d-Biotin	80 micrograms
Vitamin B_{12} supplement[1]	10 micrograms

[1]Vitamin B_{12} supplement--Propen "2.3"-contains per pound 2 grams of procaine penicillin and 3 milligrams of vitamin B_{12}. Merck and Company, Incorporated, Rahway, New Jersey.

TABLE III

EXPERIMENTAL DESIGN SHOWING THE CALORIE-PROTEIN RATIOS OF THE RATIONS USED IN THE SIX FEEDING TRIALS

		Trial																				
		I			II			III				IV				V			VI			
		Protein (percent)																				
Calorie-protein ratios (M.E.)[1]		28	32	36	28	32	36	26	28	33	36	26	28	33	36	28	33	36	28	30	32	34
	42							R5*	R8	R11	R14		R8	R11	R14							
	46							R6	R9	R12	R15	R6*	R9	R12	R15							
Control	48	RC[2]			RC				RC				RC			RC			RC			
	50																			R17*	R20	R23
	52																			R18	R21	R24
	55							R7*	R10	R13	R16	R7	R10	R13	R16		R13*	R16		R19	R22	R25
	56	R2*	R3	R4	R2*	R3	R4															
	58																					R26

[1](M.E.)-metabolizable energy, Titus (1955).
[2]RC-control ration.
*R2 to R26-experimental rations.

Corn starch replaced glucose (Cerelose) in Trials III, IV, V and VI. The use of Cerelose as a source of energy was believed to be the cause of an above normal incidence of pendulous-crop poults in Trials I and II. Lockhart (1955) found the average pH of four pendulous-crop poults to be 4.4, and the average pH of the crops of four normal poults to be 5.86. The increase in crop acidity indicated an abnormal bacterial or fermentative action within the crop. This caused a weakening of the crop muscles which made it impossible for the muscles to contract sufficiently to allow complete emptying of the crop. The body weight gains of the pendulous-crop poults were comparable to the normal poults. These body weight gains were used in the statistical analyses of these feeding trials. As a result of this procedure the accuracy of these analyses was decreased. The author believes, however, that the use of all data afforded a more precise analysis than would have been possible if affected poults had been removed and approximate corrections made for feed consumption.

Chemical analyses of the experimental rations are shown in Table IV. The 33 and 36 percent protein experimental rations with a Calorie-protein ratio of 55:1 were assayed microbiologically by the methods of Violante, Sirny and Elvehjem (1952) for eleven essential amino acids. The amino acid values are shown in Table V. The analyses were used as a basis for calculating the amino acid intake per bird at weekly intervals during the 56-day growing period.

Lot means of body weight gains of Trials I, II and III were examined statistically by the analysis of variance, Snedecor (1955). Trial IV was an eight week floor trial similar to Trial III, which was conducted in batteries. At the time this trial was initiated, the facilities were

TABLE IV

COMPOSITION OF RATIONS

Trials		I	I,II	I,II	I,II	III	III, IV	III, IV	III, IV	III, IV	III, IV	III, IV	III, IV	III, IV,V
Ration number		1	2	3	4	5	6	7	8	9	10	11	12	13
Ingredients*		Parts of total ration												
Basal	I	71.55	71.55	71.55	71.55	56.55	56.55	56.55	56.55	56.55	56.55	56.55	56.55	56.55
	II	79.05	79.05	79.05										
	III	71.55	71.55	71.55										
Dried whole egg solids			10.0	20.0	25.0				10.0	10.0	10.0	20.0	20.0	20.0
Cerelose (glucose)		31.5	20.0	6.0										
Corn starch							15.0	20.0		22.0	16.0		20.0	8.0
Stabilized animal tallow			2.5	6.0	7.0	0.5	2.0	6.0	2.0	4.0	10.0	2.0	5.0	12.0
Pulverized oats						20.0	20.0	20.0	10.0	10.0	10.0			5.0
Ground oat hulls						24.5	8.0		23.5			23.5		
d-Biotin (mgms. per hundred weight)		900	900	900	420	420	420	540	540	540	660	660	660	660

*Unit of measure is pound(s) unless otherwise specified.

Calculated analyses													
Protein (percent)	23	28	32	36	26	26	26	28	28	28	33	33	33

Calorie-protein ratio	40	56	56	56	42	46	55	42	46	55	42	46	55
Chemical analyses						Percent							
Crude protein	22.6	27.8	33.4	39.3	26.9	25.3	27.1	29.6	28.9	30.1	31.7	33.3	33.3
Ether extract	11.9	14.7	18.1	19.6	13.8	14.5	16.9	17.5	19.1	25.4	21.7	25.3	25.4
Crude fiber	11.6	1.8	2.7	2.5	6.7	7.4	4.7	3.0	3.0	3.4	9.7	2.8	2.5
Calcium	2.49	2.62	2.46	2.56	1.84	1.90	1.84	1.86	1.86	1.82	1.74	2.04	2.10
Phosphorus	1.14	1.15	1.31	1.23	1.18	1.37	1.14	1.17	1.37	1.27	1.17	1.18	1.48
Moisture	8.63	9.15	8.47	8.0	7.5	8.0	8.4	7.0	8.5	7.3	6.9	6.9	8.10

TABLE IV (Continued)

COMPOSITION OF RATIONS

Trials	III, IV	III, IV	III, IV,V	VI	VI	VI	VI	VI	VI	VI	VI	VI	VI
Ration number	14	15	16	17	18	19	20	21	22	23	24	25	26
Ingredients*	Parts of total ration												
Basal	56.55	56.55	56.55	64.55	64.55	64.55	64.55	64.55	64.55	64.55	64.55	64.55	64.55
Dried whole egg solids	25.0	25.0	25.0	14.0	14.0	14.0	18.0	18.0	18.0	22.0	22.0	22.0	22.0
Corn starch		15.0	7.0	13.5	18.5	15.5	14.5	8.5	11.5	6.0	3.5	3.5	3.5
Stabilized animal tallow	2.0	6.0	15.0			3.0		3.0	6.0	4.5	7.0	10.0	12.0
Pulverized oats				10.0	5.0	5.0	5.0	5.0		5.0	5.0	2.0	
Ground oat hulls	20.0												
d-Biotin (mgms. per hundred weight)		300	600	900				300	300	300	600	600	600

*Unit of measure is pound(s) unless otherwise specified.

Calculated analyses													
Protein (percent)	36	36	36	30	30	30	32	32	32	34	34	34	34

Calorie-protein ratio	42	46	55	50	52	55	50	52	55	50	52	55	58
Chemical analyses		Percent											
Crude protein	34.1	34.3	35.4										
Ether extract	20.0	27.7	30.3										
Crude fiber	11.9	2.3	2.5										
Calcium	2.0	1.94	1.88										
Phosphorus	1.49	1.49	1.43										
Moisture	7.9	7.7	7.4										

TABLE V

SUMMARY OF AMINO ACID ANALYSES OF 33 AND 36 PERCENT PROTEIN RATIONS WITH A CALORIE-PROTEIN RATIO OF 55:1

Amino acid	Grams per 100 grams of ration		Grams per 16 grams of nitrogen	
	33 percent	36 percent	33 percent	36 percent
Arginine	1.15	1.45	3.5	4.0
Glycine	0.63	0.53	1.9	1.5
Histidine	0.40	0.49	1.2	1.4
Isoleucine	0.89	1.07	2.7	3.0
Leucine	1.26	1.57	3.8	4.4
Lysine	1.12	1.34	3.4	3.7
Methionine	0.40	0.56	1.2	1.6
Phenylalanine	0.77	1.03	2.3	2.9
Threonine	0.73	0.82	2.2	2.3
Tryptophan	0.35	0.36	0.66	0.625
Valine	1.12	1.23	3.40	3.40

not available to replicate each treatment. The author chose to run the complete design without replication. Therefore, no statistical analysis was made on this trial. Trial V was analyzed by the multiple range test using the method of Duncan (1955). The data of Trial VI were analyzed by the Doolittle method of covariance as outlined by Dwyer (1951). Summary of the analyses will be discussed in the results of each trial.

FEEDING TRIALS

Trial I

Purpose: Trial I was initiated to develop a highly concentrated semi-purified type basal ration, which could be used to study the effect of dietary energy on the protein requirements of growing turkeys.

Procedure: This trial consisted of 12 experimental rations and a control or natural type ration (Table VI). The composition of the three basal rations used is shown in Table I. These basals were designated as I Drackett, II Feather meal and III Casein. Each of the basal rations contained 23 percent of protein with a Calorie-protein ratio of 40:1 in terms of metabolizable energy. The experimental rations (R1, R2, R3, R4), formulated by modifying each of the three basal rations (Table IV), contained protein levels of 23, 28, 32 and 36 percent, respectively, with a Calorie-protein ratio of 56:1.

Each experimental ration was fed to duplicate lots. Ten straight-run White Holland poults were used per lot. Twenty-six conventional battery brooder pens with raised wire floors were used. Initial poult weights were recorded at the beginning of the feeding trial, and individual body weights and feed consumption per lot were recorded at weekly intervals throughout the four-week feeding period.

Results: A summary of the body weight and feed conversion data obtained during the four-week growing period is given in Table VII and Figure I. The weight gain data were examined statistically according to

TABLE VI

COMPOSITION OF PRACTICAL TYPE RATION

Ingredients		Parts of total ration
Ground yellow corn		47
Pulverized oats		3
Dehydrated alfalfa meal (17% protein)		2.5
Menhaden fish meal (60% protein)		12.5
Soybean oil meal (44% protein)		15.0
Meat and bone scrap (50% protein)		10.0
Dried brewers yeast[1]		2.0
Dried whey		2
Dried condensed fish solubles		2
Calcium carbonate		1
Trace mineral mix[2]		0.05
Salt (NaCl)		0.50
VC-55[3]		0.50
Pen-bac X[4]		0.70
Vigofac[5]		0.25
NF-180[6]		0.05
	Total	99.05
<u>Chemical Analysis</u>		
Crude protein		28.1
Ether extract		4.5
Crude fiber		3.2
Calcium		2.5
Phosphorus		1.3
Calorie-protein ratio		48

FOOTNOTES

1. Live yeast culture replaced dried brewers yeast unit for unit in Trials IV, V and VI. Diamond V. Mills, Incorporated, Cedar Rapids, Iowa.

2. Trace mineral mix--see footnote 5, Table I.

3. VC-55--vitamin concentrate which adds per pound of finished ration: vitamin A, 4,000 I.U.; vitamin D_3, 2,000 I.C.U.; riboflavin, 3 mgms.; pantothenic acid, 4.0 mgms.; niacin, 20 mgms.; choline chloride, 300 mgms.; vitamin B_{12}, 3.0 mcgms.; procaine penicillin, 2.0 mgms. and menadione, 3.0 mgms.

4. Pen-bac X--see footnote 7, Table I.

5. Vigofac--a fermentation source of unidentified growth factors. Chas. Pfizer and Company, Incorporated, Terre Haute, Indiana. Vigofac was replaced in Trials IV, V and VI with Fermacto, 0.75 pound. Fermacto dried extracted streptomyces fermentation residue. The Borden Company, Feed Supplements Department, New York 17, New York.

6. NF-180--see footnote 6, Table I.

TABLE VII

SUMMARY OF TRIAL I, THE EFFECT OF DRACKETT, FEATHER MEAL AND CASEIN PROTEIN SUPPLEMENTS ON GROWTH AND EFFICIENCY OF FEED CONVERSION OF WHITE HOLLAND POULTS TO FOUR WEEKS OF AGE

Approximate calculated analyses			4 week period				
				Body weight gain			
Ration	Protein (percent)	Calorie-protein ratio (M.E.)	Average body weight grams*	Males grams	Females grams	Both sexes grams	Feed conversion[1]
Control	28	48	576(18)	547	491	519	1.68
1-BI[2]	23	40	469(18)	367	453	410	1.28
2	28	56	660(20)	645	508	577	1.31
3	32	56	692(19)	654	620	637	1.26
4	36	56	701(20)	712	577	644	1.19
1-BII[3]	23	40	145(13)	86	79	82	4.26
2	28	56	170(13)	110	120	115	3.40
3	32	56	295(18)	243	224	233	1.80
4	36	56	304(20)	262	209	235	1.70
1-BIII[4]	23	40	392(20)	365	317	341	1.95
2	28	56	636(19)	578	584	581	1.64
3	32	56	688(20)	660	594	627	1.42
4	36	56	661(19)	635	576	606	1.28

*( )Number of birds surviving the experimental period.

[1]Feed conversion is the total cumulative feed consumption divided by the total cumulative gain.

[2]BI-basal I-Drackett.

[3]BII-basal II-Feather meal.

[4]BIII-basal III-Casein.

Trial I

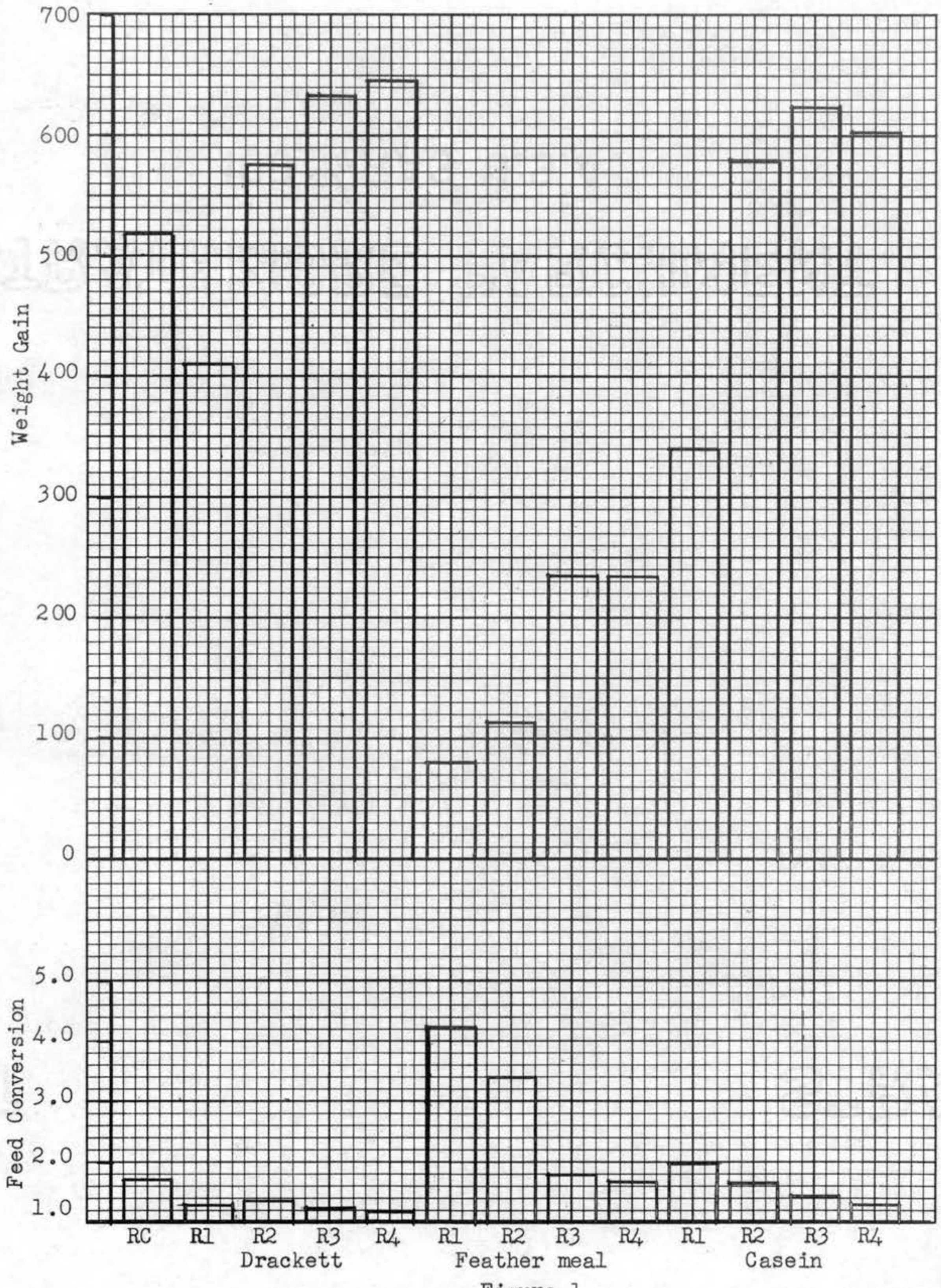

Figure 1
Body Weight Gain and Feed Conversion of Poults in Trial I
During a 28-Day Period

the method of analysis of variance, Snedecor (1955). The statistical analyses of these data are presented in Table VIII. There were highly

TABLE VIII

ANALYSIS OF VARIANCE OF FOUR-WEEK BODY-WEIGHT GAINS OF WHITE HOLLAND POULTS IN TRIAL I

Source of variation	d f	Sum of squares	Mean square	F value	Probability level
Total sum of squares	23	1,041,911.59	--	--	--
Ration	2	813,399.40	406,699.7	44.36	$P<0.005$
Protein	3	192,900.45	64,300.15	7.01	$P<0.01$
Ration X protein	6	24,609.76	4,101.63	4.47	$P<0.025$
Error (between lots in treatments)	12	11,001.98	916.83	--	--

significant differences ($P<0.005$) among rations. A part of the difference was due to a growth depression obtained with the level of feather meal studied. The 22.5 parts of feather meal were necessary to provide a protein level equivalent to either Drackett or Casein. The Drackett C-1 assay protein had to be washed with distilled water, dried at 50-60 degrees C. and ground. This protein supplement then gave a greater growth response than did the Casein supplement. However, the water-washing process presented a problem. The drying facilities were not available which would permit the use of this protein supplement throughout the experiment. Therefore the author chose to use the Casein protein supplement, which gave approximately the same results with the type of basal ration studied. The Casein supplement, at the 15 percent level tested, indicated an amino acid imbalance. Hegsted et al. (1941)

indicated that certain diets containing 18 percent of Casein were found to be primarily deficient in arginine and glycine.

A comparison of the four-week body weight gains for both Casein and Drackett basals indicated that the best growth was obtained at the 32 percent level of protein. However, the efficiency of feed conversion continued to increase at the 36 percent protein level with the same Calorie-protein ratio. Statistical analyses of body weight gains, as shown in Table VIII, indicated an interaction between ration and protein ($P < 0.025$). This was probably due to the wide difference in the three basal rations studied.

Trial II

Purpose: This trial was designed to measure the growth promoting value of the basal III when fed to poults during a 56-day growing period.

Procedure: This feeding trial consisted of three experimental rations (R2, R3, R4) and a control or natural type ration (RC). The experimental rations (Table IV) contained 28, 32 and 36 percent of protein with a Calorie-protein ratio of 56:1.

Each experimental ration was fed to duplicate lots. Thirty straight-run White Holland poults were used per lot. Eight floor pens in a tile brooder house were used. The feeding trial was initiated on March 1, 1956, and continued for a 56-day growing period. Initial poult weights were recorded at the beginning of the feeding trial, and individual body weights and feed consumption by lots were recorded at weekly intervals throughout the 56-day feeding period.

Results: A summary of the body-weight gain and feed conversion data obtained during the eight-week growing period is given in Table IX and Figure II. The weight gain data were examined statistically according to the method of analysis of variance, Snedecor (1955). These statistical analyses are presented in Table X. There were highly significant differences ($P < 0.005$) among the experimental rations. A part of the differences may have been brought about by errors in the body weights of the poults which had the pendulous-crop condition. These pendulous crops were caused by the glucose (Cerelose) in the rations. However, as the protein level was increased from 28 to 36 percent, an improvement in body weight gains was obtained at a Calorie-protein ratio of 56:1. Body weight gain for the 36 percent protein ration was only 110 grams greater than that of the 32 percent protein ration. The efficiency of feed conversion continued to improve as the protein level was increased at this Calorie-protein ratio. Body weight gain was greater with the control ration, which contained 28 percent of protein and a Calorie-protein ratio of 48:1, than with the experimental ration which contained 28 percent of protein and a Calorie-protein ratio of 56:1. Part of this decrease in growth obtained with the experimental ration could be explained by the wider Calorie-protein ratio. In addition, the experimental ration may have had an amino acid imbalance or a deficiency of amino acids at the 28 percent level of protein. However, the feed conversion obtained with the experimental ration was 1.91 as compared to 2.27 with the control ration. Ferguson *et al*. (1957) indicated that feed conversion continued to improve at each protein level as the energy level was increased.

TABLE IX

SUMMARY OF TRIAL II, THE GROWTH RESPONSE AND EFFICIENCY OF FEED CONVERSION OF WHITE HOLLAND POULTS TO EIGHT WEEKS OF AGE WHEN FED EXPERIMENTAL RATIONS FORMULATED FROM BASAL III

Approximate calculated analyses			8 week period				
				Body weight gain			
Ration	Protein (percent)	Calorie-protein ratio (M.E.)	Average body weight grams	Males grams	Females grams	Both sexes grams	Feed conver-sion
Control	28	48	2881(51)	2328	1920	2124	2.27
2	28	56	2077(55)	2299	1739	2019	1.91
3	32	56	2270(55)	2398	2027	2212	1.79
4	36	56	2381(55)	2576	2068	2322	1.70

TABLE X

ANALYSIS OF VARIANCE OF EIGHT-WEEK BODY-WEIGHT GAINS OF WHITE HOLLAND POULTS IN TRIAL II

Source of variation	d f	Sum of squares	Mean square	F value	Probability level
Total sum of squares	7	103,641.02	--	--	--
Treatment	3	99,595.96	33,198.65	32.83	$P<0.005$
Error (between lots in treatments)	4	4,045.06	1,011.27	--	--

Trial II

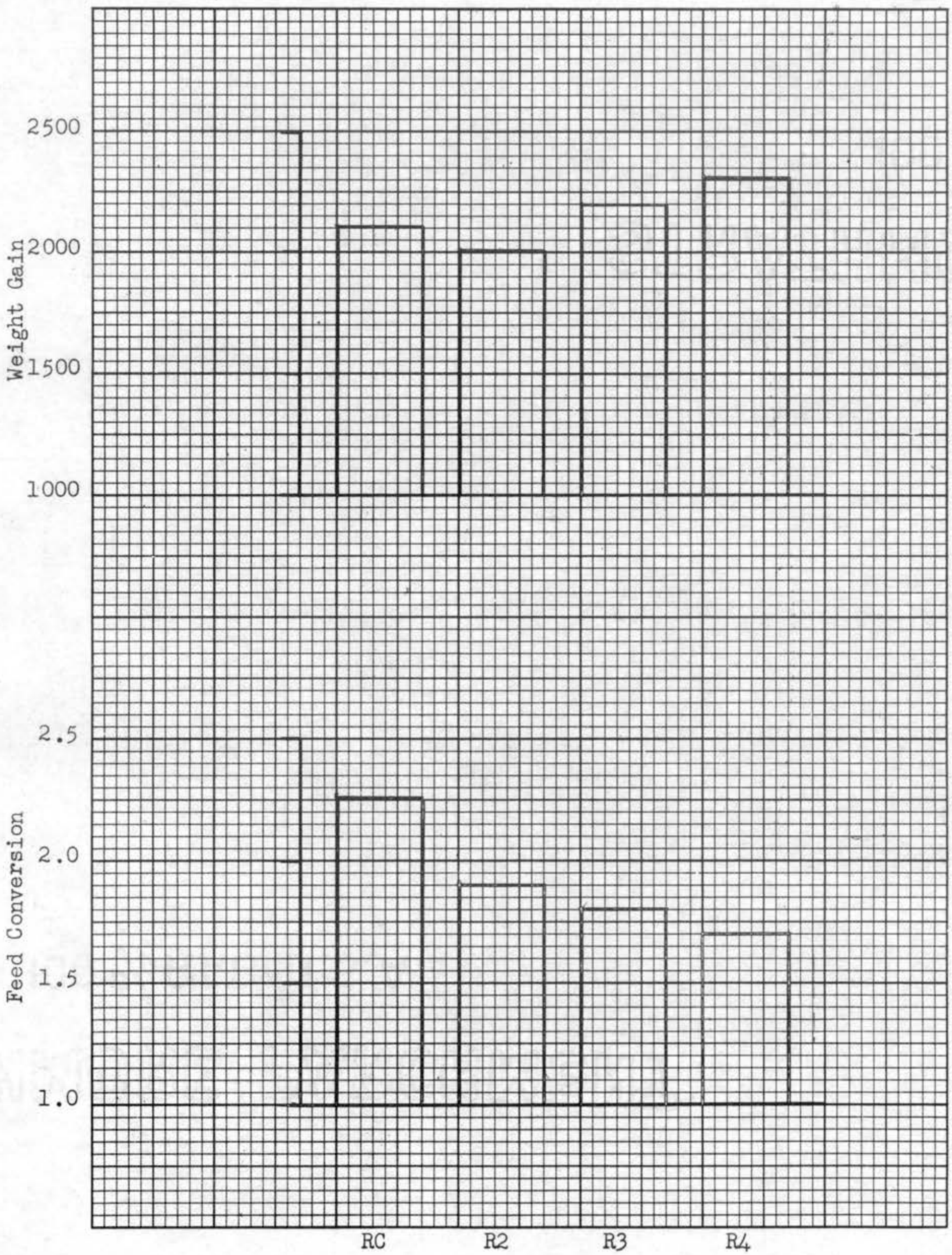

Figure 2
Body Weight Gain and Feed Conversion of Poults in Trial II
During a 56-Day Period

Trial III

Purpose: The purpose was to determine the Calorie-protein ratio in terms of metabolizable energy which was required to support the most efficient protein utilization at each of the protein levels studied during a 21-day growing period.

Procedure: This feeding trial consisted of 12 experimental rations (R5, R6, R7, R8, R9, R10, R11, R12, R13, R14, R15, R16) and a control or natural type ration (RC). The experimental rations (Table IV) contained protein levels of 26, 28, 33 and 36 percent, with Calorie-protein ratios of 42, 46 and 55:1 for each of the protein levels.

Each experimental ration was fed to duplicate lots. Ten straight-run White Holland poults were used per lot. Twenty-six battery brooder pens with raised wire floors were used. Initial poult weights were recorded at the beginning of the feeding trial, and individual body weights and feed consumption by lots were recorded at weekly intervals throughout the 21-day feeding period.

Results: A summary of body weight gains and efficiency of feed conversion of the 21-day growing period is given in Table XI and Figure III. Statistical analyses (Table XII) were made on body weight gain data. Gains obtained with Calorie-protein ratios of 42, 46 and 55:1 were significantly different ($P < 0.005$). This could be attributed, in part, to the addition of finely ground oat hulls to the rations (R5, R6, R8, R9, R11, R12, R14, R15); oat hulls were added to reduce the

TABLE XI

SUMMARY OF TRIAL III, THE GROWTH RESPONSE AND EFFICIENCY OF FEED CONVERSION OF WHITE HOLLAND POULTS TO THREE WEEKS OF AGE WHEN FED RATIONS CONTAINING CALORIE-PROTEIN RATIOS OF 42, 46 AND 55:1 AT PROTEIN LEVELS OF 26, 28, 33 AND 36 PERCENT

Approximate calculated analyses			3 week period				
				Body weight gain			
Ration	Protein (percent)	Calorie-protein ratio (M.E.)	Average body weight grams	Males grams	Females grams	Both sexes grams	Feed conver-sion
Control	28	48	433(16)	394	346	370	1.44
5	26	42	312(20)	262	237	250	1.88
6	26	46	373(19)	332	295	313	1.51
7	26	55	378(20)	320	315	317	1.42
8	28	42	372(18)	309	309	309	1.70
9	28	46	432(20)	388	356	372	1.27
10	28	55	444(19)	388	375	381	1.27
11	33	42	367(20)	309	300	304	1.62
12	33	46	442(20)	388	368	378	1.31
13	33	55	460(19)	435	359	397	1.20
14	36	42	425(17)	385	338	361	1.49
15	36	46	461(20)	401	394	397	1.23
16	36	55	478(19)	411	417	414	1.20

Trial III

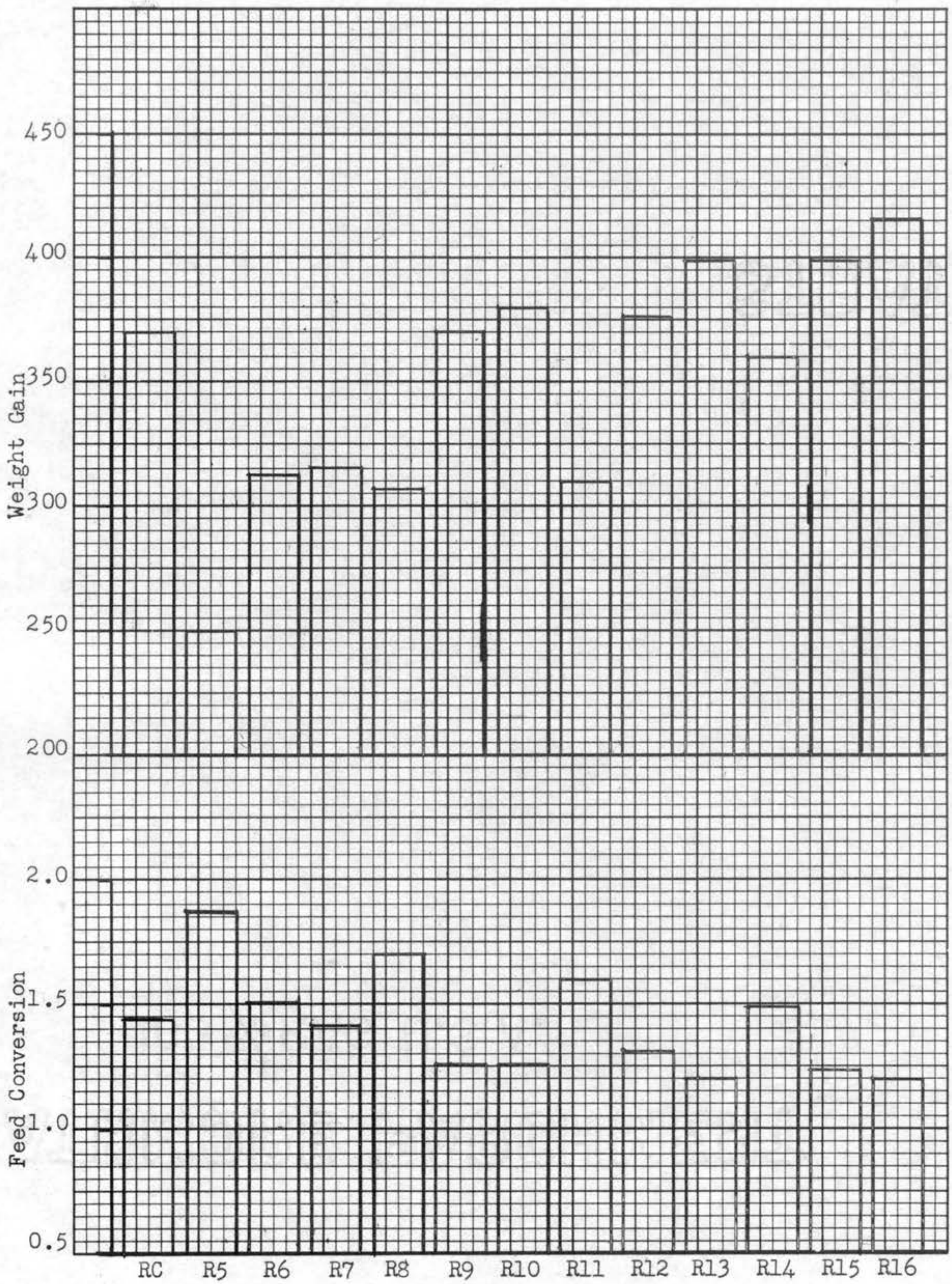

Figure 3
Body Weight Gain and Feed Conversion of Poults in Trial III
During a 21-Day Period

energy level and to obtain Calorie-protein ratios of 42 and 46:1. However, these rations (R13, R16), which contained a Calorie-protein ratio of 55:1, contained from 10 to 15 percent of pulverized oats. Anderson and Hill (1954) obtained an increased growth rate when oat hulls at levels up to 30 percent were added to high energy chick diets. In this study the body weight gain of poults fed the 26 percent protein ration with a Calorie-protein ratio of 42:1 was 120 grams less than the control ration. However, as the Calorie-protein ratio was increased at the 26 percent protein level both body weight gain and efficiency of feed conversion increased.

TABLE XII

ANALYSIS OF VARIANCE OF THREE-WEEK BODY-WEIGHT GAINS OF WHITE HOLLAND POULTS IN TRIAL III

Source of variation	d f	Sum of squares	Mean square	F value	Probability level
Total sum of squares	23	61,158.56	--	--	--
Energy	2	22,515.02	11,257.51	21.13	$P<0.005$
Protein	3	31,190.66	10,396.89	19.52	$P<0.005$
Energy X protein	6	1,060.28	176.71	0.33	--
Error (between lots in treatments)	12	6,392.6	532.72	--	--

The 28 percent protein ration with a Calorie-protein ratio of 46:1 gave comparable results to the control ration. At this protein level, as the energy level was increased there was an increase in body weight gains. However, the most efficient feed conversion was obtained at a Calorie-protein ratio of 46:1. The protein levels of 33 and 36 percent gave approximately the same results during this three-week period. As the Calorie-protein ratios were increased from 42:1 to 55:1 there was an increase in body weight gain and efficiency of feed conversion.

Trial IV

Purpose: Trial IV was conducted to determine the Calorie-protein ratio which was required to support the most efficient protein and energy utilization at each of the protein levels studied during a 56-day growing period.

Procedure: This feeding trial consisted of 11 experimental rations (R6, R7, R8, R9, R10, R11, R12, R13, R14, R15, R16) and a control or natural type ration (RC). The experimental rations (Table IV) contained protein levels of 26, 28, 33 and 36 percent with Calorie-protein ratios of 42, 46 and 55:1 for each protein level. The experimental ration (R5), with 26 percent of protein and a Calorie-protein ratio of 42:1, was omitted from this trial because of the sub-optimum growth response obtained in Trial III.

Each experimental ration was fed to individual groups. Twenty straight-run White Holland poults were used per lot. Eleven floor pens in a tile brooder house were used. The feeding trial was started on May 24, 1956, and continued for a 56-day growing period. Initial poult weights were recorded at the beginning of the feeding trial, and individual body weights and feed consumption by lots were recorded at weekly intervals throughout the 56-day feeding period.

Results: A summary of the body weight gain data and feed conversion data obtained during the eight week growing period is presented in Table XIII and Figure IV. No statistical analyses were made on these

TABLE XIII

SUMMARY OF TRIAL IV, THE GROWTH RESPONSE AND EFFICIENCY OF FEED CONVERSION OF WHITE HOLLAND POULTS TO EIGHT WEEKS OF AGE WHEN FED RATIONS CONTAINING CALORIE-PROTEIN RATIOS OF 42, 46 AND 55:1 AT PROTEIN LEVELS OF 26, 28, 33 AND 36 PERCENT

Approximate calculated analyses			8 week period				
Ration	Protein (percent)	Calorie-protein ratio (M.E.)	Average body weight grams	Body weight gain Males grams	Body weight gain Females grams	Body weight gain Both sexes grams	Feed conversion
Control	28	48	2061(18)	2216	1790	2003	1.81
6	26	46	1840(20)	1864	1694	1779	1.96
7	26	55	1842(19)	1904	1655	1780	1.71
8	28	42	1823(20)	1896	1630	1763	2.17
9	28	46	2221(19)	2425	1896	2161	1.51
10	28	55	2216(19)	2222	2087	2155	1.52
11	33	42	1833(20)	1979	1570	1775	2.20
12	33	46	2220(20)	2394	1926	2160	1.52
13	33	55	2406(20)	2612	2073	2343	1.42
14	36	42	1957(19)	2222	1560	1891	2.15
15	36	46	2364(19)	2504	2092	2298	1.50
16	36	55	2337(19)	2572	1972	2272	1.35

Trial IV

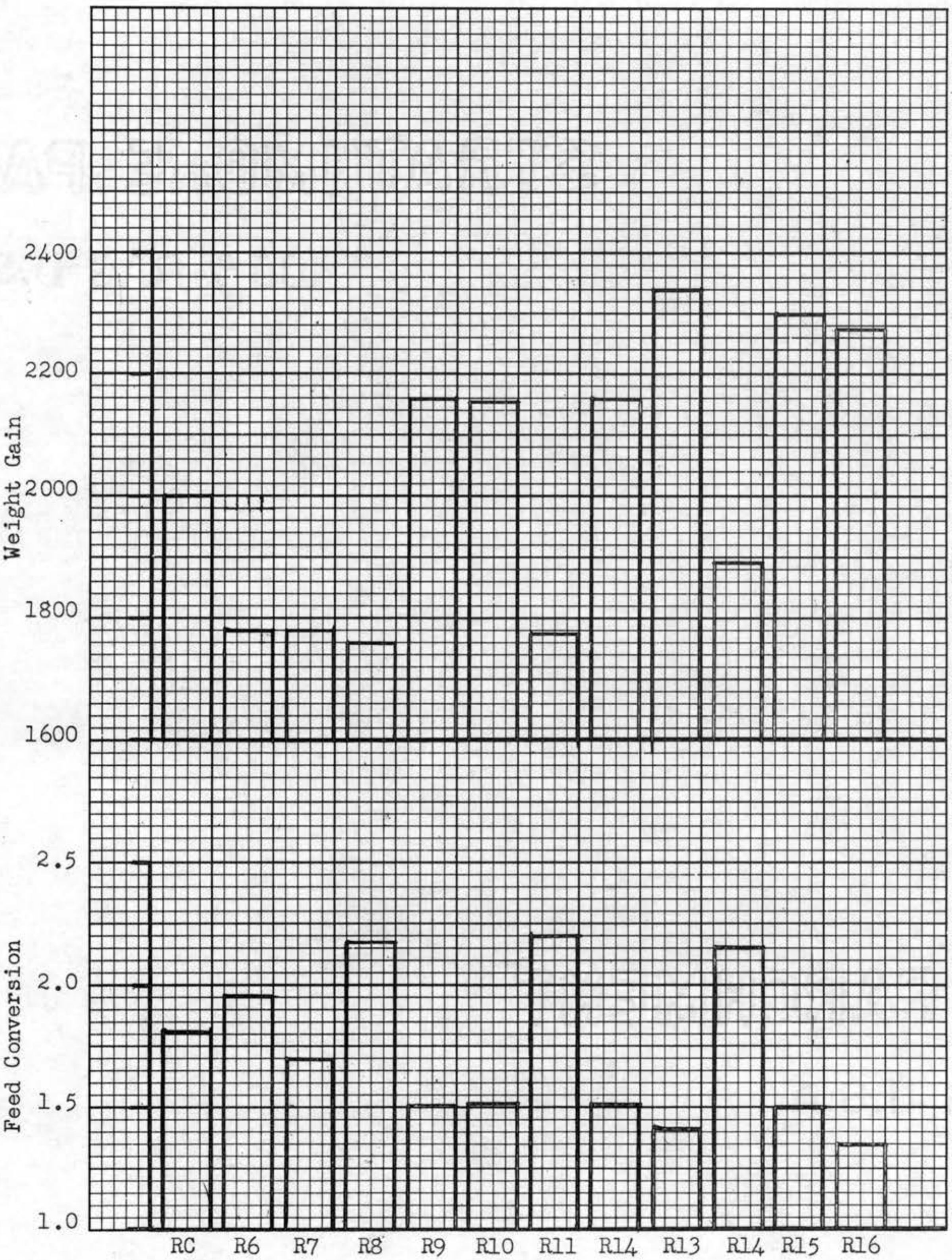

Figure 4
Body Weight Gain and Feed Conversion of Poults in Trial IV
During a 56-Day Period

data. The 56-day gains in body weight indicated that as the protein level was increased from 26 to 36 percent an increase in body weight gain resulted. An increase in growth response was obtained at each protein level up to 33 percent as the Calorie-protein ratio was increased from 42:1 to 55:1. No additional increase in weight gain was obtained at the 36 percent protein level with a Calorie-protein ratio of 55:1. Body weight gain at the 36 percent level of protein with a Calorie-protein ratio of 55:1 was 2272 grams as compared to 2343 grams at the 33 percent protein level and the same Calorie-protein ratio. However, the most efficient feed conversion was obtained at the 36 percent level of protein with a Calorie-protein ratio of 55:1.

The most efficient protein utilization (Table XIV) at eight weeks of age was obtained at 28 percent protein and a Calorie-protein ratio of 46:1. However, the most efficient protein utilization at both the 33 and the 36 percent protein levels was with a Calorie-protein ratio of 55:1.

The most efficient energy utilization (Table XIV) at eight weeks of age was obtained at 28 percent protein and a Calorie-protein ratio of 46:1. At each of the protein levels the most efficient energy utilization was at a Calorie-protein ratio of 46:1.

Best growth for the 26 percent protein level was obtained with a Calorie-protein ratio of 55:1. This ration (R7) produced poults whose average weight gain was 223 grams less than the average weight gain of the control poults. However, the efficiency of feed conversion (R7) was 1.71 as compared to 1.81 for the control ration (RC).

Maximum growth at the 28 percent protein level was obtained with a Calorie-protein ratio of 46:1. Body weight gain of both sexes was 158

TABLE XIV

CALORIES OF METABOLIZABLE ENERGY AND GRAMS OF PROTEIN REQUIRED TO PRODUCE A GRAM OF GAIN AT DIFFERENT CALORIE-PROTEIN RATIOS IN TRIAL IV

Approximate calculated analyses			4 week		6 week		8 week	
Ration	Protein (percent)	Calorie-protein ratio (M.E.)	Calories/gm. gain (M.E.)	Gm. protein/gm. gain	Calories/gm. gain (M.E.)	Gm. protein/gm. gain	Calories/gm. gain (M.E.)	Gm. protein/gm. gain
Control	28	48	4.651	0.387	4.959	0.444	5.367	0.454
6	26	46	4.629	0.457	4.734	0.467	5.150	0.508
7	26	55	5.320	0.439	4.996	0.484	5.377	0.487
8	28	42	4.880	0.527	4.992	0.539	5.621	0.607
9	28	46	3.646	0.360	3.861	0.336	4.284	0.397
10	28	55	4.338	0.358	4.515	0.373	5.153	0.425
11	33	42	5.550	0.600	6.005	0.649	6.701	0.724
12	33	46	4.279	0.422	4.514	0.445	5.086	0.502
13	33	55	4.637	0.382	5.057	0.417	5.661	0.467
14	36	42	6.018	0.650	6.431	0.695	7.154	0.775
15	36	46	4.629	0.456	4.957	0.489	5.453	0.538
16	36	55	4.714	0.389	5.142	0.425	5.905	0.487

grams above the average of the control poults. The efficiency of feed conversion was 1.51 as compared to 1.81 for the control.

Maximum growth at the 33 percent protein level was obtained with a Calorie-protein ratio of 55:1. Body weight gain of both sexes was 340 grams above the average for the control poults. The efficiency of feed conversion was 1.42 as compared to 1.81 for the controls.

Maximum growth at the 36 percent protein level was obtained with a Calorie-protein ratio of 46:1. Body weight gain of both sexes was 295 grams heavier than the average for the control poults. However, the most efficient feed conversion, 1.35, was at the Calorie-protein ratio of 55:1. These findings are in agreement with Ferguson *et al*. (1957) who reported that feed conversion continued to improve at each protein level when the energy level was increased, which could be due to a greater concentration of nutrients in the diets containing higher energy levels, Donaldson *et al*. (1957).

Trial V

Purpose: The purpose of Trial V was to determine if additional growth response could be obtained from the supplementation of the three amino acids, arginine, lysine, and tryptophan added singly and in all possible combinations with 33 and 36 percent protein rations.

Procedure: This feeding trial consisted of 16 experimental rations (R13, R16 plus all possible combinations of arginine, lysine, and tryptophan) and a control or natural type ration (RC). The experimental rations (Table IV) contained 33 and 36 percent of protein with a Calorie-protein ratio of 55:1. The three amino acids, arginine, lysine and tryptophan with all possible combinations were added at one-tenth of one percent of the L-isomer per pound of finished ration.

Each experimental ration was fed to duplicate lots. Five straight-run White Holland poults were used per lot. Thirty-four pens in conventional battery brooders with raised wire floors were used. The feeding trial was started on June 5, 1956, and continued for a four-week period. Initial body weights were recorded at the beginning, and individual body weights and feed consumption by lots were recorded at weekly intervals throughout the trial.

Results: A summary of the body weight gains and feed conversion data obtained during the four-week growing period is given in Table XV and Figure V. The body weight gain data were examined statistically according to Duncan's multiple range test (1955). Analyses of these

TABLE XV

SUMMARY OF TRIAL V, THE EFFECT OF AMINO ACID SUPPLEMENTATION ON THE GROWTH AND EFFICIENCY OF FEED CONVERSION OF WHITE HOLLAND POULTS TO FOUR WEEKS OF AGE

Approximate calculated analyses				4 week period				
					Body weight gain			
Ration	Protein (percent)	Amino acid supplement[1]	Calorie-protein ratio (M.E.)	Average body weight grams	Males grams	Females grams	Both sexes grams	Feed conversion
Control	28	None	48	556(10)	660	548	604	1.54
13	33	None	55	686(10)	680	586	633	1.24
	33	Arginine	55	749(10)	795	603	699	1.23
	33	Lysine	55	682(9)	661	603	632	1.26
	33	Tryptophan	55	706(10)	699	615	657	1.21
	33	Arg.+Lys.+Trypto.	55	701(10)	694	605	649	1.23
	33	Arg.+Lys.	55	752(10)	783	618	700	1.16
	33	Arg.+Trypto.	55	700(10)	732	563	647	1.33
	33	Lys.+Trypto.	55	653(10)	566	634	600	1.27
16	36	None	55	675(10)	711	535	623	1.30
	36	Arginine	55	778(10)	801	647	724	1.32

36	Lysine	55	748(10)	741	657	699	1.25
36	Tryptophan	55	781(10)	783	676	730	1.17
36	Arg.+Lys.+Trypto.	55	750(10)	707	687	697	1.21
36	Arg.+Lys.	55	681(10)	661	597	629	1.23
36	Arg.+Trypto.	55	754(10)	773	629	701	1.23
36	Lys.+Trypto.	55	689(10)	677	599	638	1.26

[1]Amino acids were added at a level of one-tenth of one percent of the L-isomer or the equivalent.

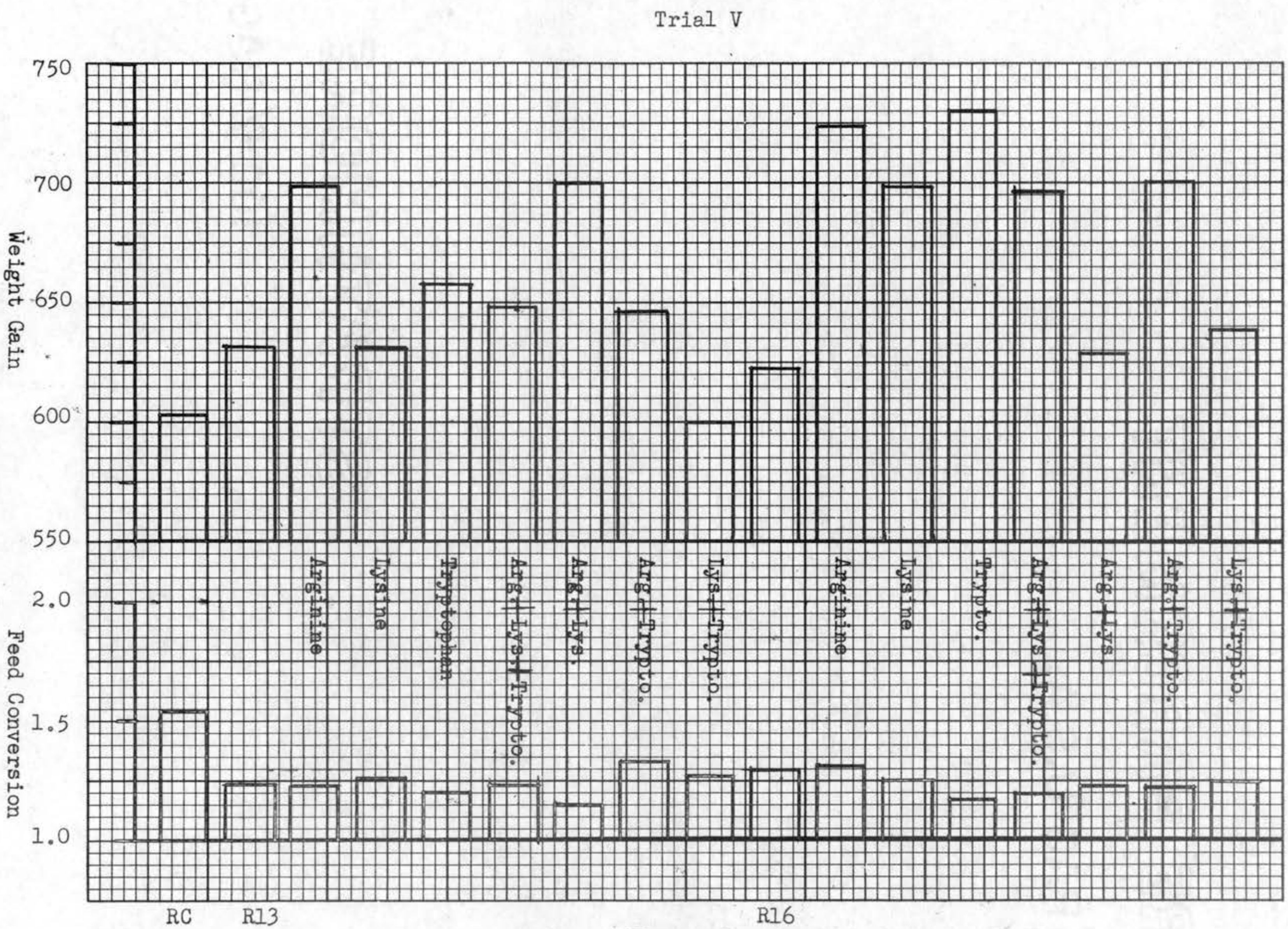

Figure 5
Body Weight Gain and Feed Conversion of Poults in Trial V
During a 28-Day Period

results are presented in Table XVI and XVII. Supplementation of the 33 percent protein ration (R13) with arginine, lysine and tryptophan or any possible combination of these three amino acids did not result in an increase in growth rate over the non-supplemented ration. However, lysine plus tryptophan gave a slight growth depression at this protein level. Ferguson _et al_. (1956) also obtained this same growth depression with a 21.7 percent protein basal diet supplemented with a combination of lysine plus tryptophan.

TABLE XVI

ANALYSIS OF VARIANCE OF FOUR-WEEK BODY-WEIGHT GAINS OF WHITE HOLLAND POULTS IN TRIAL V

Source of variation	d f	Sum of squares	Mean square
Total sum of squares	33	97,648.1	--
Treatment	16	76,827.02	4,801.69
Error (between lots in treatments)	17	20,821.08	1,224.77

The 36 percent protein ration (R16) supplemented with arginine, lysine, tryptophan or any possible combination of the three amino acids gave no significant growth response over the original ration with no supplementation. The supplementation of the amino acids lysine plus tryptophan failed to give a growth depression at this protein level. Ferguson _et al_. (1956) also noted that this growth depression was not present at the higher protein levels in the presence of methionine. Poults fed the ration with the supplementation of the amino acid tryptophan obtained the most efficient feed conversion, 1.17.

TABLE XVII

DUNCAN'S MULTIPLE RANGE TEST OF BODY WEIGHT GAIN DATA OF WHITE HOLLAND POULTS AT FOUR WEEKS OF AGE IN TRIAL V

$$Sm = \sqrt{\frac{EMS}{k}} = \sqrt{\frac{1224.77}{2}} = \sqrt{612.39} = 24.747 \qquad n_2 = 17$$

p:	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Rp: .05	73.7	77.5	79.7	81.2	82.4	83.1	83.6	84.1	84.6	84.9	85.1	85.3	85.4	85.5	85.6	85.7
.01	102	106	109	111	113	115	116	117	118	118.2	118.8	119.2	119.5	119.9	120	120.6

L+T[1]	Con.[3]	B[4]	A+L	L	B	L+T	A+T	A+L+T	T	A+L+T	L	A	A+L	A+T	A	T
33[2]	28	36	36	33	33	36	33	33	33	36	36	33	33	36	36	36
600	604	623	629	632	633	638	647	649	657	697	698.8	699	700	701	724	730

.05

.01

[1]Amino acid abbreviation.
A = arginine
L = lysine
T = tryptophan

[2]Protein level.

[3]Con. = control ration.

[4]B = basal with no supplementation.

Trial VI

Purpose: This trial was designed to determine if a narrower Calorie-protein ratio would support more efficient protein and energy utilization at each of the protein levels studied during a 56-day growing period.

Procedure: This feeding trial consisted of ten experimental rations (R17, R18, R19, R20, R21, R22, R23, R24, R25, R26) and a control or natural type ration (RC). The experimental rations (Table IV) contained protein levels of 30, 32 and 34 percent with Calorie-protein ratios of 50, 52, 55:1 for each protein level. An exception was made at the 34 percent protein level where four Calorie-protein ratios of 50, 52, 55 and 58:1 were used. This addition was made to determine if an increase in energy at the higher protein level would give any additional growth response.

Each experimental ration was fed to duplicate lots within two brooder houses. Ten straight-run Broad Breasted Bronze poults were used per pen. Twelve floor pens in a tile brooder house and twelve floor pens in a frame brooder house were used. The trial was started on September 26, 1956, and conducted for a 56-day growing period. Initial poult weights were recorded at the beginning, and individual body weights and feed consumption by lots were recorded at weekly intervals throughout the trial.

Results: A summary of the body weight gain and feed conversion data obtained during the eight-week growing period is given in Table XVIII and Figure VI. The body weight gain and feed conversion data were

TABLE XVIII

SUMMARY OF TRIAL VI, THE GROWTH RESPONSE AND EFFICIENCY OF FEED CONVERSION OF BROAD BREASTED BRONZE POULTS TO EIGHT WEEKS OF AGE WHEN FED RATIONS CONTAINING CALORIE-PROTEIN RATIOS OF 50, 52, 55 AND 58:1 AT PROTEIN LEVELS OF 30, 32 AND 34 PERCENT

Approximate calculated analyses			8 week period				
				Body weight gain			
Ration	Protein (percent)	Calorie-protein ratio (M.E.)	Average body weight grams	Males grams	Females grams	Both sexes grams	Feed conversion
Control	28	48	2145(39)	2317	1850	2084	1.85
17	30	50	2192(19)	2373	1888	2131	1.51
18	30	52	2088(18)	2191	1863	2027	1.51
19	30	55	2085(17)	2128	1927	2028	1.39
20	32	50	1965(20)	2166	1642	1904	1.55
21	32	52	1969(20)	2050	1768	1909	1.42
22	32	55	1977(18)	2098	1691	1919	1.40
23	34	50	2004(16)	2226	1659	1943	1.45
24	34	52	1997(17)	2079	1789	1934	1.36
25	34	55	1923(16)	2083	1640	1861	1.31
26	34	58	1954(18)	2185	1606	1896	1.26

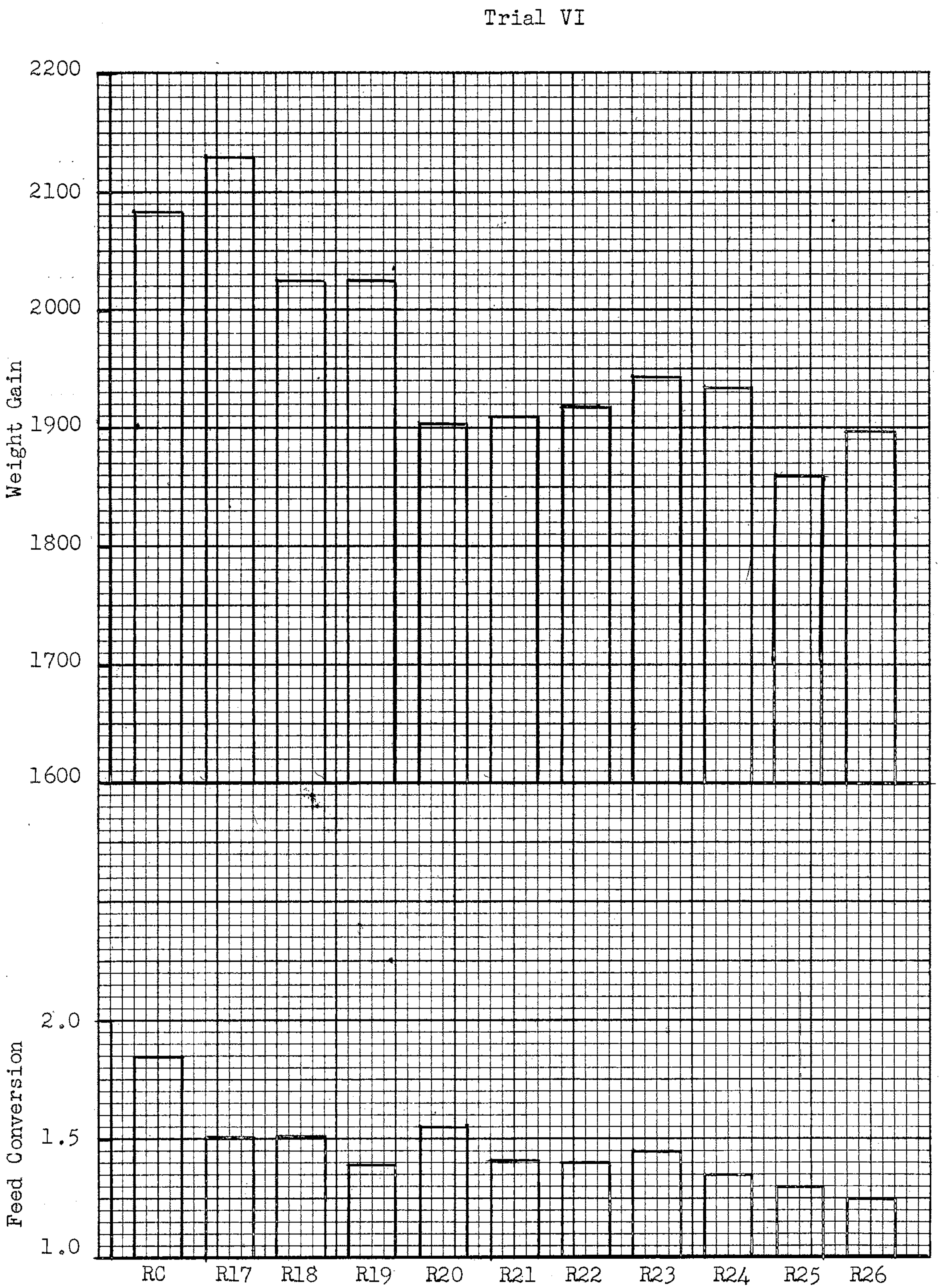

Figure 6
Body Weight Gain and Feed Conversion of Poults in Trial VI
During a 56-Day Period

examined statistically according to the Doolittle method of analysis, Dwyer (1951) (Table XIX). The analyses of the weight gain data did not reveal any significant differences at the protein and energy levels tested. However, there were significant differences among feed conversion values tested. There was an interaction between energy and protein at the levels tested. This would tend to indicate that efficiency of feed conversion continued to increase at each level of protein in the presence of increased energy levels.

Feed conversion appears to be directly related to the energy level of the ration, regardless of the protein level. However, the most efficient feed conversion was obtained at the 34 percent protein level. Lockhart and Thayer (1955) and Ferguson _et al_. (1956) reported that the most efficient feed conversion did not correspond to the greatest gain in body weight. However, if the protein is not adequate to utilize a given energy level to provide optimum growth, a smaller bird will result.

The most efficient protein utilization (Table XX) was obtained at the Calorie-protein ratios of 55 and 58:1 at each protein level tested. However, the most efficient energy utilization was not obtained at these Calorie-protein ratios. The most efficient energy utilization was obtained with a different Calorie-protein ratio at each of the protein levels tested.

These data tended to indicate that females required a higher energy level than did males for optimum growth at each of the protein levels tested. The Calorie-protein ratio for females was more critical as the protein level was increased from 30 to 34 percent. These data with females would tend to contradict the idea of Atkinson _et al_. (1957) that as the protein level is lowered the Calorie-protein ratio becomes more critical.

TABLE XIX

ANALYSIS OF VARIANCE OF EIGHT-WEEK BODY-WEIGHT GAINS AND CUMULATIVE EFFICIENCY OF FEED CONVERSION OF POULTS FED PROTEIN LEVELS OF 30, 32 AND 34 PERCENT WITH CALORIE-PROTEIN RATIOS OF 50, 52, 55 AND 58:1

Gains

Source of variation	d f	Sum of squares	Mean square	F value	Probability level
Total sum of squares	19	278,347.75	--	--	
Treatment	9	120,532.58	13,392.51	--	
Protein unadjusted	2	24,382.84	12,191.42	--	
Energy adjusted for protein	3	2,550.20	850.07	--	
Protein X energy adjusted for energy and protein	4	93,599.54	23,399.89	1.483	
Error	10	157,815.17	15,781.52	--	

Feed conversion

Source of variation	d f	Sum of squares	Mean square	F value	Probability level
Total sum of squares	19	0.18071	--	--	
Treatment	9	0.14825	0.0165	--	
Protein unadjusted	2	0.01694	0.0085	--	
Energy adjusted for protein	3	0.01679	0.0056	--	
Protein X energy adjusted for energy and protein	4	0.11452	0.0286	8.82	P< 0.005
Error	10	0.03246	0.0032	--	

TABLE XX

CALORIES OF METABOLIZABLE ENERGY AND GRAMS OF PROTEIN REQUIRED TO PRODUCE A GRAM OF GAIN AT DIFFERENT CALORIE-PROTEIN RATIOS IN TRIAL VI

Approximate calculated analyses			4 week		6 week		8 week	
Ration	Protein (percent)	Calorie-protein ratio (M.E.)	Calories/gm. gain (M.E.)	Gm. protein/gm. gain	Calories/gm. gain (M.E.)	Gm. protein/gm. gain	Calories/gm. gain (M.E.)	Gm. protein/gm. gain
Control	28	48	4.121	0.413	4.665	0.481	5.028	0.519
17	30	50	4.260	0.387	4.738	0.430	4.974	0.452
18	30	52	4.215	0.368	4.762	0.416	5.191	0.454
19	30	55	4.653	0.384	5.002	0.412	5.063	0.418
20	32	50	4.444	0.404	5.075	0.461	5.466	0.497
21	32	52	4.268	0.373	4.806	0.419	5.221	0.456
22	32	55	4.549	0.375	5.055	0.417	4.947	0.448
23	34	50	4.578	0.416	4.982	0.452	5.427	0.493
24	34	52	4.439	0.388	4.892	0.428	5.292	0.462
25	34	55	4.521	0.373	5.053	0.417	5.407	0.447
26	34	58	4.618	0.351	5.077	0.398	5.491	0.430

DISCUSSION

Data obtained in this series of feeding trials indicate that maximum growth was obtained with an experimental ration which contained 33 percent of protein with a Calorie-protein ratio of 55:1. The most efficient feed conversion, however, was obtained at the 36 percent level of protein with a Calorie-protein ratio of 55:1. Growth response at this higher protein level was slightly lower than that obtained at the 33 percent level of protein. This would indicate that growth plateaued at approximately 33 percent of protein, but efficiency of feed conversion continued to improve as the protein level was increased. Better amino acid balance with a greater concentration of nutrients would explain, in part, the increased efficiency of feed conversion at the higher protein level.

It is obvious from these data that the nutritive requirements for energy and protein are very critical during the first eight weeks of the growing period. It was observed that the Calorie-protein ratio which produced the most efficient feed conversion and the most rapid gain was different for each of the protein levels studied. This is in agreement with Sunde (1956). At the lower Calorie-protein ratios, where energy was not adequate, significant decreases in growth response and significant increases in feed consumption were noted. Hill and Dansky (1954) reported that feed consumption was determined primarily by the energy level of the diet.

When the Calorie-protein ratio was increased from 42:1 to 58:1, less protein was required per unit of gain. This indicated a sparing effect of energy on protein. The most efficient protein utilization was obtained at Calorie-protein ratios of 55:1 and 58:1 at all except one of the protein levels studied. At the 28 percent level of protein, a Calorie-protein ratio of 46:1 was required for optimum results. However, the most efficient energy utilization was obtained at a lower Calorie-protein ratio. These data indicate that the most efficient energy utilization was obtained with a Calorie-protein ratio between 46:1 and 50:1 at each of the protein levels studied. Donaldson et al. (1956) obtained increased growth and improved calorie utilization until the protein level was increased above that required for maximum growth. However, the author believes that it is more important to obtain the most efficient protein utilization rather than maximum energy utilization because of the relatively high cost of protein supplements as compared to energy sources.

This study indicates that male and female poults differ widely in their protein and energy requirements. This may mean that each sex will be grown in separate pens and fed rations balanced to fit their specific nutritive requirements. These results indicated that male poults require a higher protein level with a lower Calorie-protein ratio for their maximum growth. Conversely, the female poults require a lower protein level with a higher Calorie-protein ratio for their maximum growth.

No Calorie-protein ratio recommendations can be made from this study. It is apparent from these data, however, that more research work must be done in order to determine the optimum energy requirements of growing turkeys.

Amino acid supplementation in this study did not significantly improve growth response at 33 and 36 percent levels of protein. There was some indication of a slight growth response at the 36 percent level of protein. The best growth response was obtained at the 36 percent level of protein with arginine and tryptophan added singly. The tryptophan supplementation at this protein level produced the most efficient feed conversion. These results indicated that the amino acid requirements which are presently being recommended, in some instances, are below normal for the most rapid growth response and the most efficient feed conversion.

During the first two weeks of the growing period it was possible to produce one unit of gain on nine-tenth of one unit of feed. As greater knowledge is obtained about nutrient interrelationships, it could be possible to extend these results further into the growing period. This could mean that we will feed market turkeys according to their physiological age, rather than their chronological age.

SUMMARY AND CONCLUSIONS

Fourteen hundred straight-run Broad Breasted Bronze and White Holland poults were fed rations containing protein levels of 23, 28, 30, 32, 33, 34 and 36 percent with Calorie-protein ratios as outlined in Table III. Maximum growth was obtained with 33 percent of protein and a Calorie-protein ratio of 55:1. The most efficient feed conversion was obtained with 36 percent of protein and a Calorie-protein ratio of 55:1. The most efficient protein utilization was obtained with a Calorie-protein ratio of 55:1 at all except one of the protein levels studied.

The 33 and 36 percent protein rations were supplemented with the amino acids arginine, lysine and tryptophan added singly and in all possible combinations. Amino acid supplementation in this study did not significantly improve growth response at 33 and 36 percent levels of protein. There was some indication, however, that a greater growth response was obtained at the 36 percent level of protein. This would indicate that interrelationships among all amino acids play an important role at this higher protein level. These data indicate that the amino acid requirements are higher than presently recommended for maximum growth and most efficient feed conversion, at the protein levels studied.

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