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To the Graduate Council:

I am submitting herewith a thesis written by John Bradley Rose entitled "Lysine and Methionine Supplementation of Peanut Meal Diets for Chickens". I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Poultry.

J K Bletner
Major Professor

We have read this thesis
and recommend its acceptance:

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LYSINE AND METHIONINE SUPPLEMENTATION OF PEANUT MEAL DIETS FOR CHICKENS

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

John Bradley Rose

March 1963

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TABLE OF CONTENTS

	PAGE
INTRODUCTION	1
OBJECTIVES	4
LITERATURE REVIEW	5
Peanut Meal in the Diets of Chicks	5
Peanut Meal in the Layer Diet	11
MATERIALS AND METHODS	15
Broiler Diet Studies	15
Battery Studies	16
Experiment I	17
Experiment II	18
Experiment III	18
Experiment IV	18
Experiment V	24
Floor Studies	24
Experiment VI	27
Layer Diet Studies	29
Experiment VII	29
RESULTS	34
Broiler Diet Studies	34
Battery Studies	34
Experiment I	34
Experiment II	36
Experiment III	36

PAGE

Experiment IV 39
Experiment V 41
Floor Studies 43
Experiment VI 43
Layer Diet Studies 45
Experiment VII 45
DISCUSSION 50
Broiler Diet Studies 50
Layer Diet Studies 56
SUMMARY 58
REFERENCES 61

LIST OF TABLES

TABLE		PAGE
I.	Composition of Diets Used in Experiment I	19
II.	Composition of the Vitamin Mix Used in Chick Diets	20
III.	Composition of the Mineral Mix Used in Chick Diets	21
IV.	Composition of Diets Used in Experiment II	22
V.	Composition of Diets Used in Experiment III	23
VI.	Composition of Diets Used in Experiment IV	25
VII.	Composition of Diets Used in Experiment V	26
VIII.	Composition of Diets Used in Experiment VI	28
IX.	Composition of Diets Used in Experiment VII	31
X.	Composition of Vitamin Mix Used in Layer Diets . .	32
XI.	Composition of Mineral Mix Used in Layer Diets . .	33
XII.	Adjusted Average Body Weights and Feed Conversion Ratios of Chicks at Four Weeks of Age Experiment I	35
XIII.	Adjusted Average Body Weights and Feed Conversion Ratios of Chicks at Four Weeks of Age Experiment II	37
XIV.	Adjusted Average Body Weights and Feed Conversion Ratios of Chicks at Four Weeks of Age Experiment III	38

TABLE PAGE

XV. Adjusted Average Body Weights and Feed Conversion Ratios of Chicks at Four Weeks of Age Experiment IV 40

XVI. Adjusted Average Body Weights and Feed Conversion Ratios of Chicks at Four Weeks of Age Experiment V 42

XVII. Average Body Weights and Feed Conversion Ratios of Chicks at Eight Weeks of Age Experiment VI 44

XVIII. Average Body Weights of Chicks by Weeks Experiment VI 46

XIX. Average Feed Consumption Per Chick by Weeks Experiment VI 47

XX. Summary of the Response of Layers to Lysine and Methionine Supplementation in a Corn-Fish Meal-Peanut Meal Diet 48

XXI. Summary of Adjusted Average Body Weights in Grams of Five Battery Experiments with Different Levels of Supplemental Amino Acids 51

INTRODUCTION

Vegetable protein concentrates are being used as a feed in the livestock industry throughout the world to an ever increasing extent. Soybeans and peanuts are major sources of these protein concentrates in the temperate and tropical zones of the world.

One of the protein concentrates derived from soybeans is known as dehulled solvent extracted soybean oil meal which has been defined as "the product resulting from dehulled solvent extracted soybean flakes. It shall contain not more than 3 percent crude fiber and shall be designated and sold according to its protein content." Peanut meal is ground peanut cake (the product obtained after the extraction of part of the oil by pressure or solvents from peanut kernels as produced under reasonable milling conditions) provided that nothing shall be recognized as such that contains more than 11 percent crude fiber. It must be designated and sold according to its protein content.

As an unsupplemented vegetable protein concentrate in poultry feed, soybean oil meal has not been excelled by any other single vegetable protein. The average proximate analysis of high grade soybean oil meal (dehulled) is reported to be 50 percent crude protein, 3 percent crude fiber, 0.2 percent calcium, 0.6 percent phosphorus, 0.87 percent methionine, 0.68 percent cystine and 3.0 percent lysine. High grade peanut meal on the other hand would show 50 percent protein, 7 percent crude fiber,

0.2 percent calcium, 0.6 percent phosphorus, 0.49 percent methionine, 0.77 percent cystine and 1.4 percent lysine. A comparison of these two vegetable protein concentrates indicates that peanut meal might be more effectively used in the livestock industry if it were supplemented by both lysine and methionine.

The protein requirement of the chicken is essentially an amino acid requirement. It is recognized at present that the chicken requires at least twelve amino acids in the diet for rapid growth. The requirement of the laying hen in this respect is not well defined, but it is generally accepted that ten essential amino acids are required for maximum egg production. Both growth and egg production are adversely affected if these essential amino acids are not provided in the diet in proper amounts and in balance.

Most vegetable proteins contain all the essential amino acids required by poultry, but, unfortunately, they are not found in the proportion or at the levels that induce most rapid growth or maximum egg production. This necessitates the supplementation of the vegetable protein with another protein rich in the deficient amino acid, or the addition of the amino acid itself if the vegetable protein is to be used most effectively in the diet of the chicken. Peanut meal is a rich source of protein for poultry diets but is deficient in both lysine and methionine.

The requirement of both lysine and methionine for growth and egg production has been determined using various practical

and purified diets. It has also been demonstrated that the availability of an amino acid varies in different feedstuffs as well as different combinations of feedstuffs.

The results of numerous studies indicate that peanut meal may be used as a major source of protein supplement in the diets of chicks and layers when such diets are fortified with amino acids, vitamins, and minerals. Since some of the amino acids are relatively expensive, it is desirable to know the minimum level of amino acid supplementation which will produce maximum growth, egg production and feed efficiency if peanut meal is to be used most efficiently. There appears to be a dearth of literature concerning this problem.

India ranks first in the world in the production of peanuts and produces large amounts of peanut meal. At present a sizable quantity of this meal is used as a fertilizer or is exported. With the increasing expansion of the livestock industry, especially poultry, there is an increased need for suitable high protein supplements. Peanut meal, if adequately supplemented, gives promise of meeting the requirements of such a high grade protein supplement.

A series of experiments was conducted to determine the minimum supplementary dietary requirement of lysine and methionine for maximum growth and feed efficiency in broiler chicks fed a corn-fish meal-peanut meal diet and to determine the necessity of supplementary lysine and methionine for maximum egg production and feed efficiency in Leghorn-type pullets fed a corn-fish meal-peanut meal diet.

OBJECTIVES

The objectives of this study were:

(1) To determine the minimum level of supplementary lysine and methionine in a corn-fish meal-peanut meal diet for maximum growth and feed efficiency in broilers.

(2) To compare the laying house performance of Single Comb White Leghorn-type pullets fed a corn-fish meal-peanut meal diet with and without supplementary lysine and methionine with that of pullets fed a corn-fish meal-soybean oil meal diet.

LITERATURE REVIEW

Peanut Meal in the Diet of Chicks

Peanut meal when used as the major source of protein or as a substitute for meat scrap in the diet of growing chicks has been reported to lower growth rate. Bryant (1931) replaced all the meat scrap in the diet of growing chicks with peanut meal. The lot receiving peanut meal as the sole protein supplement made only about one-half the growth of the control group. Goff and Penquite (1930-32) reported that chicks receiving 20 percent peanut meal and 10 percent corn gluten meal as the protein supplement in their diet made the least gains and were in the poorest condition. King and Cottier (1937) also reported that peanut meal in the diet of chicks as the sole protein supplement resulted in an unsatisfactory rate of growth. Heuser et al. (1945) found that Single Comb White Leghorn chicks grew more rapidly when fed soybean oil meal than when fed wheat germ meal or peanut meal when these vegetable proteins were used as the major source of protein.

Studies have been conducted in which peanut meal has been used as a substitute for part of the animal protein supplement in the diet of growing chicks. When Bryant (1931) replaced 25 and 50 percent of the meat scrap in a growing diet with peanut meal, the resulting growth was equal to that of the controls. Goff and Penquite (1930-32) replaced either the

corn gluten meal, dried buttermilk, or meat scrap in the diet with peanut meal and also replaced two of these ingredients at a time with peanut meal. They found that peanut meal could replace either corn gluten meal, dried buttermilk or meat scrap with no detrimental effect on growth. The lot receiving 20 percent peanut meal and 10 percent dried buttermilk made the largest gains in body weight. King and Cottier (1937) reported that growth rate was improved considerably where peanut products were supplemented with animal protein. When dried buttermilk and peanut products each supplied one-half of the protein supplement, the rate of growth was satisfactory.

Results of studies with peanut meal as a partial or complete substitute for vegetable protein supplements in the diet of chicks have been reported by many workers. Sherwood and Couch (1940) compared the values of various protein feeds for growing chicks. In these experiments the chicks receiving the cottonseed meal, soybean oil meal and fish meal or meat and bone scraps made more rapid gains than those fed peanut meal, soybean oil meal and fish meal or meat and bone scraps. It required about the same amount of feed to produce the gains on the different combination of feeds. Hammond (1944) concluded that in a diet properly supplemented with vitamins and minerals, 15 percent of the soybean oil meal could be replaced by an equal weight of peanut meal without affecting the growth of chicks. Marvel et al. (1944), using a diet adequate in minerals, found that peanut meal

was a satisfactory substitute for soybean oil meal in a growing diet. Driggers and Tarver (1958) found no difference in growth when 50 percent of the soybean oil meal was replaced by peanut meal (55 percent protein) in a diet containing a blend of fish meal and fish solubles. Douglas and Harms (1958) investigating the use of peanut meal as a source of protein in broiler diets found that when peanut meal replaced 50 percent of the soybean oil meal in the diet, growth was restricted. Lysine appeared to be the first limiting amino acid. Significant growth improvement was obtained by supplementing such diets with L-lysine, methionine and glycine. However, growth rate was not as good as that obtained from feeding a diet containing soybean oil meal.

Peanut meal has been shown to be low in calcium and phosphorus when compared to fish meal or meat scrap. A direct substitution of either fish meal or meat scrap in the diet with peanut meal would hence lower the mineral content and possibly the protein quality of the diet. It is interesting to note that Kennard and White (1922) reported that peanut meal could be used as a protein supplement in the diets of growing chicks, provided a suitable mineral mixture was added. The mineral mixture increased the value of peanut protein for growth by more than 40 percent.

Peanut meal when fed with an animal protein supplement has been reported to give better results than any other peanut

product. Altschul et al. (1948) reported that peanut meals support chick growth equally as well as commercial screw pressed soybean oil meal and are only slightly inferior to commercial hydraulic pressed cottonseed meal when used as the source of protein equivalent to 5.5 percent of the total diet in an otherwise adequate diet for chicks. The alkali extracted peanut meal protein and the residue left after protein extraction were not as satisfactory substitutes as peanut meal.

The identification and isolation of the animal protein factor led to a wider use of vegetable proteins, particularly soybean oil meal, as a major source of protein in the diets of growing chicks. Blaylock and Richardson (1950) supplemented a peanut meal diet with amino acids and a source of animal protein factor. Those birds that received the animal protein factor concentrate weighed approximately 100 grams more at six weeks of age than did those which did not receive the animal protein factor concentrate.

Several studies have been conducted on the amino acid supplementation of peanut meal to increase its value as a protein supplement in the diet of the chick. Grau (1946) reported that the principal amino acid deficiencies of peanut meal were lysine and methionine and possibly threonine and tryptophane. When all four amino acids were added to a basal diet containing peanut meal as a source of protein, the daily increase in body weight was 6.9 percent. When lysine was omitted, the growth

increased only 5.5 percent, but when the methionine was omitted, the resulting increase in growth rate was only 2.7 percent. Threonine and tryptophane when added to the diet had no significant effect on growth rate. Blaylock and Richardson (1950) using a basal diet containing peanut meal, milo, animal protein factor concentrates and different combinations of lysine and methionine, reported that the basal diet supplemented with 0.2 percent lysine and 0.3 percent methionine supported a growth rate equal to that of a soybean oil meal diet.

Amino acids have come to be recognized as the structural units of proteins. The growth promoting character of a protein has been reported to be due to its amino acid composition and, numerous reports have been made as to the amino acid requirement of the chick for growth. Almquist (1947) studied the amino acid requirement of the growing chick. In the presence of an adequate cystine level in the diet, Almquist found that the methionine requirement for optimum growth was close to 0.5 percent, while the requirement in the relative absence of cystine was close to 0.9 percent of the diet. Maximum growth was obtained with lysine at 0.9 percent of the diet. Milligan et al. (1951) used an all vegetable diet containing 21 percent protein, based on corn, alfalfa meal and soybean oil meal. On analysis this diet was shown to contain 0.32 percent methionine and 0.28 percent cystine. Chicks grown on this diet to six weeks of age responded with increased growth when 0.1 percent methionine was added but not with

further supplementation. However, as the supplementary level of methionine was increased up to 0.2 percent of the diet, feed efficiency improved. An estimate of total sulphur amino acid requirement on the basis of this work is 0.85 percent of which 0.52 percent must be in the form of methionine. Almquist (1952) reported that in a diet based on cereals, alfalfa meal and vegetable protein supplements, containing 21.5 to 22 percent protein and all the vitamins necessary, 0.37 percent methionine was clearly inadequate, and that 0.45 percent methionine was required for optimum growth. The National Research Council (1960) recommended 0.45 percent methionine in the presence of 0.35 percent cystine and 1.0 percent lysine in a diet containing 20 percent protein. Schwartz et al. (1957), working with fast growing broiler chicks fed a nearly practical corn-sesame diet up to four weeks of age, reported that the chick requires 1.1 percent lysine in diets containing 20.0 percent protein of good quality and 975 Calories of productive energy per pound of feed. However, it was found that the level of lysine should be reduced at a rate of about 0.05 percent per week to a minimum of 0.8 percent, since excess dietary lysine was found to impair growth and feed efficiency. It was also reported that changes in dietary energy concentration, altered the lysine requirement at the rate of 0.07 percent per 100 Calories. An increase of 3 percent in the protein level of the diet from 20.0 percent to 23.0 percent raised the lysine requirement about 0.1 percent.

Edwards et al. (1956) limited the growth of chicks by feeding graded levels of bulk and concluded that the lysine requirement was influenced by rate of gain. Griminger, according to Schwartz et al. (1957) did not find a difference in the lysine requirement of a rapid growing and slow growing strain of chicks. Klain et al. (1958), using purified diets, estimated the lysine requirement of the growing chick at 1.23 percent of the diet and methionine at 0.2 percent in the presence of 0.4 percent cystine.

It has been shown that the rate of growth of the chick is dependent on the proportions of the various amino acids in the diet. Anderson (1961) recommended a balanced supplementation of amino acids. He reported that lysine and methionine at 1.2 percent and 0.72 percent, respectively, of the diet produced maximum growth when the protein level of the diet was 20.0 percent.

Peanut Meal in the Layer Diet

Peanut meal when used to replace all the meat scrap or animal protein supplement in the diet has been reported to reduce production among layers. Harvey (1917) reported that hens fed a diet containing peanut meal as the major source of protein laid at the low rate of 33.8 percent; whereas birds fed a meat scrap diet supplying an equivalent amount of protein laid at the rate of 52.9 percent. The birds fed the meat scrap diet required about one pound less feed to produce a dozen eggs, than those

fed the peanut meal diet. Embleton (1919), using meat scrap, cottonseed meal, peanut meal and a mixture of cottonseed and peanut meals as sources of protein in a grain-mash diet, reported the highest production for the meat scrap diets, followed by the diet containing the mixture of cottonseed and peanut meals, peanut meal, and lastly cottonseed meal. The hens receiving the cottonseed meal diet suffered the highest mortality while those receiving the peanut meal the lowest. Birds fed the peanut meal diet laid the smallest eggs, whereas birds fed the cottonseed meal diet laid the largest. Stout (1926) reported an egg production of 62.4 percent for the buttermilk fed pen, 38.7 percent for the beef-scrap pen, 34.1 percent for the cottonseed meal pen and 21.6 percent for the peanut meal pen. All pens showed a decrease in body weight at the end of the experimental period of 126 days; the smallest decrease being in the buttermilk pens and the largest in the peanut meal pens. Ivey (1927) reported an average annual production of 137, 117.75, 128.6 and 113.1 eggs per layer when cottonseed meal, peanut meal, soybean oil meal and meat scraps, respectively, were used in a corn-oats-middlings mash diet, supplying a total of 13 percent digestible protein. King and Cottier (1937) found that birds fed peanut meal laid an average of 10.7 eggs per month, weighing 21.61 ounces per dozen each and averaged 3.43 pounds in body weight. Birds fed a corn-dried skim milk diet on the other hand, averaged 15.1 eggs per month, weighing 22.7 ounces per dozen each, and had an

average body weight of 3.87 pounds. The birds had access to yards which supplied seasonal green feeds and limited range. Dearstyne et al. (1940) found that replacing 62 percent to 94 percent of the animal protein with high grade peanut meal did not reduce the egg production, hatchability or livability of chickens.

Peanut meal is low in minerals, especially calcium and phosphorus and supplementation with these minerals has been reported to increase its value as a feed for the laying hen. Kennard and White (1922) reported that peanut oil meal could be used successfully as a protein supplement for egg production, provided a suitable mineral mixture was added. The mineral mixture increased the value of peanut meal more than 40 percent.

The requirement of the laying hen for certain essential amino acids has been studied by various researchers in recent years. Ingram et al. (1951a), using peanut meal supplemented with lysine and tryptophane as the source of protein, showed that the requirement of the laying hen for methionine is not more than 0.38 percent of the diet and that the combined methionine and cystine requirement is not more than 0.63 percent. Leong and McGinnis (1952) made a study of the methionine requirement of Single Comb White Leghorn pullets using Alaska peas as the principal protein source. Excellent production was maintained when the methionine level in the diet was raised to 0.28 percent with the protein level between 15 and 16 percent and the calculated cystine level at 0.25 percent. Ingram et al. (1951b)

using a corn gluten meal-corn diet containing approximately 15 percent protein, estimated the total L-lysine requirement of the laying hen for egg production as not over 0.50 percent. The National Research Council (1960) recommended a minimum of 0.5 percent lysine and 0.28 percent methionine in the presence of 0.25 percent cystine in a laying hen diet containing 15 percent protein.

MATERIALS AND METHODS

Broiler Diet Studies

Cross-bred broiler type chicks obtained from a Tennessee commercial hatchery were used in all the experiments. Chicks were sexed at one day of age, vaccinated against Newcastle disease and infectious bronchitis with a combination intra-occular vaccine, and wing banded. The all mash diets used were fed ad libitum. Water was made available at all times. The grade and quality of the ingredients used in the diets are given below:

Yellow corn: U. S. No. 2

Fish meal: Experiment I - Menhaden containing 60 percent protein; in all subsequent experiments, Peruvian containing 60 percent protein. (These two types of fish meal have been used interchangeably on the University farm.)

Alfalfa meal: 17 percent protein, dehydrated, grease treated, 100,000 IU vitamin A activity per pound

Corn gluten meal: 60 percent protein, high in xanthophyll

Soybean oil meal: 50 percent protein, dehulled, solvent extracted

Peanut meal: 50 percent protein, dehulled, solvent extracted

L-Lysine supplement: "Lyamine" (A product of Merck and Co., Inc., Rahway, New Jersey), contained 20 percent active ingredient

Manganese supplement: 75 percent anhydrous manganese sulphate

Coccidiostat: Amprol (a product of Merck and C., Inc., Rahway, New Jersey), contained 25 percent Amprolium.

The quality and/or potency of the other ingredients are shown in Tables II and III (see pages 20 and 21).

Battery Studies

All chicks were housed in electrically heated battery brooders located in three different rooms in the Nutrition Laboratory of the Poultry Department. Three of the brooders were located in one large room and were used in Experiment I, II and IV. The other two rooms had one brooder each and were used in Experiment III and V.

The temperature of the battery brooders was maintained initially at 95° F and reduced by 5° each week thereafter till room temperatures were reached. The room temperatures were maintained between 80° F and 85° F by thermostatically controlled electric wall heaters at the start of each experiment and were reduced to 75° F after four or five days. This was not possible during all the experiments as experiments IV and V were conducted during the summer when the atmospheric temperature reached a high of 97° F on certain days. Ventilation was provided by means of an exhaust fan in the corridor between the three rooms.

Five male and five female chicks were randomly assigned to each pen. Birds that died during the first week of the experimental period were replaced by birds of the same sex, maintained on a layer diet. In experiments I, II and IV, diets were

assigned to pens according to a procedure described by Cochran and Cox (1957) for use of a 6 x 5 incomplete Latin Square design and in experiments III and V according to a 5 x 4 incomplete Latin Square design.

Individual body weights of all chicks were determined in grams at the start of each experiment and at weekly intervals for the duration of the study. All battery experiments were terminated at the end of four weeks. Feed consumed by each replicate lot was also determined at the end of each experiment. A daily log of mortality, room and battery temperatures, chick conditions and other observations was maintained during each experiment.

The data were analysed according to an analysis of variance procedure suggested by Cochran and Cox (1957) for incomplete Latin Square designs in which inter-block differences are not recovered. Significant treatment differences were determined by the use of Duncan's Multiple Range Test (1955).

Experiment I. This experiment was initiated to determine the minimum level of supplementary L-lysine to be added to a broiler diet in which all the soybean oil meal had been replaced by peanut meal having the same protein content. Five peanut meal diets and a soybean oil meal control diet were used. All the peanut meal diets contained 0.2 percent added DL-methionine. Diet 62-12 was not supplemented with lysine. Diets 62-13, 62-14, 62-15 and 62-16 were supplemented with lysine at graded levels of 0.2, 0.3, 0.4 and 0.5 percent, respectively. Diet 62-17, a

soybean oil meal diet, was used as the control. The composition and calculated analysis of the six diets are given in Table I.

Experiment II. This experiment was designed to study the growth response of chicks to graded levels of methionine in a peanut meal diet supplemented with 0.1 and 0.2 percent lysine. Diets 62-23, 62-24 and 62-25 were supplemented with 0.1 percent lysine and 0.1, 0.2 and 0.3 percent methionine, respectively. Diets 62-26, 62-27, and 62-28 were supplemented with 0.2 percent lysine and 0.1, 0.2 and 0.3 percent methionine, respectively. The composition and calculated analysis of these diets are shown in Table IV. (see page 22).

Experiment III. As the chick growth response at the lowest level of lysine supplementation in Experiment I was not significantly different from the higher levels of supplementation, it was thought fit to determine the lowest level of lysine supplementation of a peanut meal diet which might give optimum growth in the presence of 0.2 percent added methionine. Thus, diets 62-29, 62-30, 62-31 and 62-32 were formulated to contain 0.2 percent methionine and 0.05, 0.1, 0.15 and 0.2 percent lysine, respectively. Diet 62-33 was a soybean oil meal diet and was used as the control. The composition and calculated analysis of the diets used are shown in Table V. (see page 23).

Experiment IV. From the three preceeding experiments it appeared that the peanut meal diets required supplementation with about 0.2 percent lysine and some methionine to produce near maximum chick growth. The exact level of methionine was not

TABLE I

COMPOSITION OF DIETS USED IN EXPERIMENT I

Ingredients	Diet number					
	62-12	62-13	62-14	62-15	62-16	62-17
Yellow corn	53.00	52.00	51.50	51.00	50.50	53.10
Fish meal	5.00	5.00	5.00	5.00	5.00	5.00
Alfalfa meal	2.50	2.50	2.50	2.50	2.50	2.50
Corn gluten meal	3.00	3.00	3.00	3.00	3.00	3.00
Soybean oil meal	--	--	--	--	--	30.00
Peanut meal	30.00	30.00	30.00	30.00	30.00	--
Yellow grease, stabilized	3.00	3.00	3.00	3.00	3.00	3.00
Vitamin mix[1]	0.60	0.60	0.60	0.60	0.60	0.60
Mineral mix[2]	2.70	2.70	2.70	2.70	2.70	2.70
L-Lysine supplement	--	1.00	1.50	2.00	2.50	--
DL-Methionine	0.20	0.20	0.20	0.20	0.20	0.10
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis:						
Crude protein, %	24.69	24.81	24.87	24.93	24.99	24.57
Methionine, %	0.59	0.58	0.58	0.58	0.58	0.50
Lysine, %	0.85	1.04	1.14	1.24	1.34	1.22
Productive energy, Calories per pound	1012	1000	995	989	983	978
C/P ratio	41.3	40.6	40.3	39.98	39.7	39.8

[1]Composition of vitamin mix used is given in Table II.

[2]Composition of mineral mix used is given in Table III.

TABLE II

COMPOSITION OF THE VITAMIN MIX USED IN CHICK DIETS

Ingredients	Pounds
Vitamin D supplement (3000 ICU/g.)	6.00
Vitamin A supplement (10,000 IU/g.)	10.00
Riboflavin supplement (24 g./lb.)	2.15
Vitamin B_{12} supplement (12 mg./lb.)	10.00
Antibiotic supplement (10 g. aureomycin/lb.)	13.00
Choline chloride supplement (25%)	45.00
Niacin	1.00
D-calcium pantothenate	0.167
Arsanilic acid supplement (20%)	10.00
Yellow corn	46.75
Total	143.90
Calculated vitamin and non-nutritive additive content per 0.6 pounds:	
Vitamin D	34,000 ICU
Vitamin A	189,167 IU
Riboflavin	0.215 g.
Vitamin B_{12}	0.498 mg.
Choline	18.42 g.
Niacin	1.828 g.
Pantothenic acid	0.318 g.
Aureomycin	0.54 g.
Arsanilic acid	3.786 g.

TABLE III

COMPOSITION OF THE MINERAL MIX USED IN CHICK DIETS

Ingredients	Pounds
Rock phosphate, defluorinated	62.5
Limestone	75.0
Salt	30.0
Manganese sulphate	1.0
Total	168.5
Calculated minerals supplied per pound:	
Calcium	0.291 lb.
Phosphorus (inorganic)	0.063 lb.
Manganese	727 mg.
Salt	0.178 lb.

TABLE IV

COMPOSTION OF DIETS USED IN EXPERIMENT II

Ingredients	Diet numbers					
	62-23	62-24	62-25	62-26	62-27	62-28
	Percent					
Yellow corn	52.6	52.5	52.4	52.1	52.0	51.9
Fish meal	5.0	5.0	5.0	5.0	5.0	5.0
Alfalfa meal	2.5	2.5	2.5	2.5	2.5	2.5
Corn gluten meal	3.0	3.0	3.0	3.0	3.0	3.0
Peanut meal	30.0	30.0	30.0	30.0	30.0	30.0
Yellow grease, stabilized	3.0	3.0	3.0	3.0	3.0	3.0
Vitamin mix[1]	0.6	0.6	0.6	0.6	0.6	0.6
Mineral mix[2]	2.7	2.7	2.7	2.7	2.7	2.7
L-Lysine supplement	0.5	0.5	0.5	1.0	1.0	1.0
DL-Methionine	0.1	0.2	0.3	0.1	0.2	0.3
Total	100.0	100.0	100.0	100.0	100.0	100.0
Calculated Analysis:						
Crude protein, %	24.63	24.73	24.83	24.69	24.79	24.89
Methionine, %	0.49	0.59	0.69	0.48	0.58	0.68
Lysine, %	0.95	0.95	0.95	1.04	1.04	1.04
Productive energy, Calories per pound	1005	1004	1003	993	998	997
C/P ratio	40.8	40.6	40.4	40.5	40.3	40.0

[1]Composition of vitamin mix used is given in Table II.

[2]Composition of mineral mix used is given in Table III.

TABLE V

COMPOSITION OF DIETS USED IN EXPERIMENT III

Ingredients	Diet numbers				
	62-29	62-30	62-31	62-32	62-33
	Percent				
Yellow corn	52.75	52.50	52.25	52.00	53.10
Fish meal	5.00	5.00	5.00	5.00	5.00
Alfalfa meal	2.50	2.50	2.50	2.50	2.50
Corn gluten meal	3.00	3.00	3.00	3.00	3.00
Soybean oil meal	--	--	--	--	30.00
Peanut meal	30.00	30.00	30.00	30.00	--
Yellow grease, stabilized	3.00	3.00	3.00	3.00	3.00
Vitamin mix[1]	0.60	0.60	0.60	0.60	0.60
Mineral mix[2]	2.70	2.70	2.70	2.70	2.70
L-Lysine supplement	0.25	0.50	0.75	1.00	--
DL-Methionine	0.20	0.20	0.20	0.20	0.10
Total	100.00	100.00	100.00	100.00	100.00
Calculated Analysis:					
Crude protein, %	24.70	24.73	24.76	24.79	24.57
Methionine, %	0.59	0.59	0.58	0.58	0.50
Lysine, %	0.90	0.95	0.99	1.04	1.22
Productive energy, Calories per pound	1007	1004	1001	998	978
C/P ratio	40.8	40.6	40.4	40.3	39.8

[1]Composition of vitamin mix used is given in Table II.

[2]Composition of mineral mix used is given in Table III.

clearly defined by the earlier experiments. It was hence decided to use this level of lysine supplementation and determine the optimum level of methionine supplementation of a peanut meal diet with graded levels of methionine. Diets 62-35, 62-36, 62-37, 62-38 and 62-39 were formulated to contain 0.2 percent lysine and 0.0, 0.2, 0.3, 0.4 and 0.5 percent supplemental methionine, respectively. Diet 62-34, a soybean oil meal diet, was used as the control. The composition and calculated analysis of these diets are given in Table VI.

Experiment V. This experiment was designed to determine whether chicks fed a peanut meal diet supplemented with 0.4 percent added lysine would respond to the addition of graded levels of methionine. Hence, diets 62-41, 62-42, 62-43 and 62-44 were formulated to contain 0.4 percent added lysine with 0.0, 0.2, 0.4 and 0.6 percent added methionine. The composition and calculated analysis of the diets used are shown in Table VII. Diet 62-40, the soybean oil meal diet, was used as a control.

Floor studies

This experiment was conducted in floor pens. The experimental period was eight weeks. The brooder house contained twenty pens. The temperature of the room and ventilation were controlled by three roof exhaust fans equiped with a thermostat and an automatic time clock. The feeders and waterers were changed to meet the needs of the growing birds. The chicks were brooded under infra-red lamps. Wood shavings were used as litter in one half of the pens and bark wool in the other half.

TABLE VI

COMPOSITION OF DIETS USED IN EXPERIMENT IV

Ingredients	Diet numbers					
	62-34	62-36	62-36	62-37	62-38	62-39
	Percent					
Yellow corn	53.10	52.20	52.00	51.90	51.80	51.70
Fish meal	5.00	5.00	5.00	5.00	5.00	5.00
Alfalfa meal	2.50	2.50	2.50	2.50	2.50	2.50
Corn gluten meal	3.00	3.00	3.00	3.00	3.00	3.00
Soybean oil meal	30.00	--	--	--	--	--
Peanut meal	--	30.00	30.00	30.00	30.00	30.00
Yellow grease, stabilized	3.00	3.00	3.00	3.00	3.00	3.00
Vitamin mix[1]	0.60	0.60	0.60	0.60	0.60	0.60
Mineral mix[2]	2.70	2.70	2.70	2.70	2.70	2.70
L-Lysine supplement	--	1.00	1.00	1.00	1.00	1.00
DL-Methionine	0.10	--	0.20	0.30	0.40	0.50
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis:						
Crude protein, %	24.57	24.61	24.79	24.89	24.97	25.07
Methionine, %	0.50	0.38	0.58	0.68	0.78	0.88
Lysine, %	1.22	1.04	1.04	1.04	1.04	1.04
Productive energy, Calories per pound	978	1000	998	997	996	995
C/P ratio	39.8	40.6	40.3	40.0	39.9	39.7

[1]Composition of vitamin mix used is given in Table II.

[2]Composition of mineral mix used is given in Table III.

TABLE VII

COMPOSITION OF DIETS USED IN EXPERIMENT V

Ingredients	Diet numbers				
	62-40	62-41	62-42	62-43	62-44
	Percent				
Yellow corn	53.10	51.20	51.00	50.80	50.60
Fish meal	5.00	5.00	5.00	5.00	5.00
Alfalfa meal	2.50	2.50	2.50	2.50	2.50
Corn gluten meal	3.00	3.00	3.00	3.00	3.00
Soybean oil meal	30.00	--	--	--	--
Peanut meal	--	30.00	30.00	30.00	30.00
Yellow grease, stabilized	3.00	3.00	3.00	3.00	3.00
Vitamin mix[1]	0.60	0.60	0.60	0.60	0.60
Mineral mix[2]	2.70	2.70	2.70	2.70	2.70
L-Lysine supplement	--	2.00	2.00	2.00	2.00
DL-Methionine	0.10	--	0.20	0.40	0.60
Total	100.00	100.00	100.00	100.00	100.00
Calculated Analysis:					
Crude protein, %	24.57	24.73	24.91	25.09	25.27
Methionine, %	0.50	0.38	0.58	0.78	0.98
Lysine, %	1.22	1.24	1.24	1.24	1.24
Productive energy, Calories per pound	978	989	987	984	982
C/P ratio	39.8	39.98	39.6	39.2	38.9

[1]Composition of vitamin mix used is given in Table II.

[2]Composition of mineral mix used is given in Table III.

Forty-nine male and forty-nine female chicks were used in each replicate lot. All chicks used in the floor studies were de-beaked. The individual day-old weights of a sample of 49 male and 49 female chicks indicated no unusual variability in weight for chicks of this breeding.

Group weights of males and females in each replicate lot were recorded at weekly intervals up to the seventh week. At the end of the experimental period, the birds were individually weighed and the weights recorded. Sexing errors were also recorded.

A randomized block design of five treatments and four replicates was used in the experiment. The data were analyzed according to an analysis of variance suggested by Snedecor (1956). Significant treatment differences were determined by the use of Duncan's Multiple Range Test (1955).

Experiment VI. Results of the battery experiments gave an indication of the levels of lysine and methionine supplementation of a peanut meal diet for maximum growth; the most promising of these were selected and used in the floor experiment. Thus, diets BR-17 (0.15 percent lysine and 0.2 percent methionine supplementation), BR-18 (0.2 percent lysine and 0.2 percent methionine supplementation), BR-19 (0.4 percent lysine and 0.2 percent methionine) and BR-20 (0.4 percent lysine and 0.4 percent methionine) were formulated. Diet BR-16 was a soybean oil meal diet and was used as the control. The composition and calculated analysis of all diets used in this experiment are given in Table VIII.

TABLE VIII

COMPOSITION OF DIETS USED IN EXPERIMENT VI

Ingredients	Diet numbers				
	BR-16	BR-17	BR-18	BR-19	BR-20
	Percent				
Yellow corn	53.10	51.75	51.50	50.50	50.30
Fish meal	5.00	5.00	5.00	5.00	5.00
Alfalfa meal	2.50	2.50	2.50	2.50	2.50
Corn gluten meal	3.00	3.00	3.00	3.00	3.00
Soybean oil meal	30.00	--	--	--	--
Peanut meal	--	30.00	30.00	30.00	30.00
Yellow grease, stabilized	3.00	3.00	3.00	3.00	3.00
Vitamin mix[1]	0.60	0.60	0.60	0.60	0.60
Mineral mix[2]	2.70	2.70	2.70	2.70	2.70
Amprol	0.50	0.50	0.50	0.50	0.50
L-Lysine supplement	--	0.75	1.00	2.00	2.00
DL-Methionine	0.10	0.20	0.20	0.20	0.40
Total	100.00	100.00	100.00	100.00	100.00
Calculated Analysis:					
Crude protein, %	24.57	24.72	24.75	24.87	25.05
Methionine, %	0.50	0.58	0.58	0.58	0.78
Lysine, %	1.22	0.99	1.04	1.24	1.24
Productive energy, Calories per pound	978	995	992	981	978
C/P ratio	39.8	40.3	40.1	39.4	39.1

[1]Composition of vitamin mix used is given in Table II.

[2]Composition of mineral mix used is given in Table III.

Layer Diet Studies

Experiment VII. This experiment was conducted with mature Leghorn-type pullets in laying cages. The house contained four double rows of cages, and the southernmost row of 420 cages was used for the experiment. Each group of fifteen cages constituted one pen. Two pens in the center and two pens at the western end of the row were not used and left vacant throughout the experiment. The sides of the house were covered with plastic sheets to protect the birds during the winter months. A record of individual hen egg production, weekly individual egg weights, feed consumption by pens and mortality was kept throughout the experimental period. The experiment was conducted for a period of six and one half months.

Three hundred and sixty Single Comb White Leghorn-type pullets were selected from a total of 415 birds and alloted to individual cages so that each pen of fifteen birds had about the same percent production over a pre-experimental test period of forty-five days. All birds were weighed and their weights recorded at the beginning and end of the experiment.

Four diets and six replicates were used in the experiment. Diet LR I, a soybean oil meal diet, was the laying diet used at the University of Tennessee Poultry Farm and served as the control. Diets EL-29, EL-30 and EL-31 had the same composition except that the soybean oil meal and a small amount of corn were replaced by solvent extracted peanut meal (45 percent) to supply an

equivalent amount of protein in the diets. Diet EL-29 was a corn-fish meal-peanut meal diet, diet EL-30 was the same diet supplemented with enough lysine to bring it to the same calculated lysine level as diet LR-1 and diet EL-31 was supplemented with both lysine and methionine to bring it to the same calculated levels as diet LR-1. Feed and water were supplied ad libitum. The quality of the feedstuffs used was similar to that used in the earlier experiments, except for the peanut meal which was known commercially as "45 percent peanut meal and peanut hulls (solvent extracted)." The composition of the four diets is shown in Table IX. The composition of the vitamin mix and mineral mix used are shown in Tables X and XI.

TABLE IX

COMPOSITION OF DIETS USED IN EXPERIMENT VII

Ingredients	Diet numbers			
	LR-1	EL-29	EL-30	EL-31
Yellow corn	72.00	70.00	68.55	68.49
Fish meal	2.50	2.50	2.50	2.50
Alfalfa meal	5.00	5.00	5.00	5.00
Vitamin mix[1]	0.50	0.50	0.50	0.50
Mineral mix[2]	3.00	3.00	3.00	3.00
Soybean oil meal	17.00	--	--	--
Peanut meal	--	19.00	19.00	19.00
Oyster shell, hen size	8.00	8.00	8.00	8.00
L-Lysine supplement	--	--	1.45	1.45
DL-Methionine	--	--	--	0.06
Total	108.00	108.00	108.00	108.00
Calculated Analysis (based on 100 pounds of diet without oyster shell):				
Crude protein, %	17.36	17.53	17.60	17.66
Methionine, %	0.34	0.28	0.28	0.34
Lysine, %	0.88	0.59	0.88	0.88
Productive energy, Calories per pound	973	984	967	966
C/P ratio	56.0	56.1	55.9	55.8

[1]Composition of vitamin mix used is given in Table X.

[2]Composition of mineral mix used is given in Table XI.

TABLE X

COMPOSITION OF VITAMIN MIX USED IN LAYER DIETS

Ingredients	Pounds
Vitamin D supplement (3000 ICU/g.)	40.0
Vitamin A supplement (10,000 IU/g.)	10.0
Riboflavin supplement (24 g./lb.)	2.3
Vitamin B_{12} supplement (12 mg./lb.)	10.0
Niacin	1.0
D-Calcium pantothenate	0.167
Yellow corn	136.7
Total	200.0
Calculated vitamin content per 0.5 pound:	
Vitamin D	134,187 ICU
Vitamin A	111,823 IU
Riboflavin	0.134 g.
Vitamin B_{12}	0.295 mg.
Niacin	1.097 g.
Pantothenic acid	0.191 g.

TABLE XI

COMPOSITION OF MINERAL MIX USED IN LAYER DIETS

Ingredients	Pounds
Rock phosphate, defluorinated	150.0
Limestone	100.0
Salt	50.0
Manganese sulphate	2.5
Total	302.5
Calculated minerals supplied per pound:	
Calcium	0.29 pounds
Phosphorus (inorganic)	0.084 pounds
Salt	0.165 pounds
Manganese	1215 mg.

RESULTS

Broiler Diet Studies

Battery Studies

Experiment I. The results of this study are summarized in Table XII. The average body weight of chicks fed diets 62-13 (0.2 percent lysine and 0.2 percent methionine), 62-14 (0.3 percent lysine and 0.2 percent methionine) 62-15 (0.4 percent lysine and 0.2 percent methionine), and 62-16 (0.5 percent lysine and 0.2 percent methionine) did not differ significantly from those fed diet 62-17 (soybean oil meal control). Diet 62-12 (0.0 percent lysine and 0.2 percent methionine) produced chicks with significantly lighter body weights than did the other five diets.

Feed efficiency in this and subsequent broiler experiments has been calculated on the units of feed required per unit of body weight at the end of the experimental period. The feed efficiency of the chicks fed diets 62-13, 62-14, 62-15, 62-16 and 62-17 was better and significantly different at the 5 percent level of probability from that of chicks fed diet 62-12. At the 1 percent level of probability the feed efficiency of chicks fed diet 62-17 was significantly better than those fed diet 62-12. There was no significant difference in feed efficiency between those lots of chicks fed diets 62-12, 62-13, 62-14, 62-15 and 62-16. Diets 62-13, 62-14, 62-15, 62-16 and 62-17 also had

TABLE XII

ADJUSTED AVERAGE BODY WEIGHTS AND FEED CONVERSION RATIOS OF CHICKS AT FOUR WEEKS OF AGE
EXPERIMENT I

Diet number[1]	Supplemental amino acids in the diet		Average body weights[2]	Feed/weight[2]
	L-lysine	DL-methionine		
	Percent		Grams	
62-17	(soybean oil meal, control)		579.03[a]	1.59[a]
62-16	0.5	0.2	575.40[a]	1.63[ab]
62-13	0.2	0.2	565.90[a]	1.60[ab]
62-14	0.3	0.2	549.49[a]	1.63[ab]
62-15	0.4	0.2	549.28[a]	1.63[ab]
62-12	--	0.2	487.92[b]	1.75[b]

[1]Composition and calculated analysis given in Table I.

[2]Means with different superscripts are significantly different at the 1% level of probability as calculated by Duncan's Multiple Range Test (1955).

similar feed conversion values which were not significantly different.

Experiment II. The results of this experiment are summarized in Table XIII. Chicks fed diet 62-28 (0.2 percent lysine and 0.3 percent methionine) had significantly heavier average body weights than chicks fed diets 62-23 (0.1 percent lysine and 0.1 percent methionine), 62-24 (0.1 percent lysine and 0.2 percent methionine), and 62-25 (0.1 percent lysine and 0.3 percent methionine) at both the 5 and 1 percent levels of probability. It was also found that chicks fed diet 62-26 (0.2 percent lysine and 0.1 percent methionine) and diet 62-27 (0.2 percent lysine and 0.2 percent methionine) produced chicks with heavier body weights than those fed diets 62-23 (0.1 lysine and 0.1 methionine) and 62-25 (0.1 lysine and 0.3 methionine). These differences were significant at both the 5 and 1 percent levels of probability. Chicks fed diets 62-26, 62-27 and 62-28 did not differ significantly in body weights at the end of four weeks. Similarly, no statistical differences in average body weight were found among diets 62-24, 62-26 and 62-27. Chicks fed diets 62-23, 62-24 and 62-25 had the lightest average body weights and did not differ significantly from one another. No significant differences were found between the feed conversion ratios of the chicks fed any of the diets.

Experiment III. The results of this experiment are summarized in Table XIV. The average weight of chicks fed diet

TABLE XIII

ADJUSTED AVERAGE BODY WEIGHTS AND FEED CONVERSION RATIOS OF CHICKS AT FOUR WEEKS OF AGE EXPERIMENT II

Diet number[1]	Supplemental amino acids in the diet		Average body weights[2]	Feed/weight[2]
	L-lysine	DL-methionine		
	Percent		Grams	
62-28	0.2	0.3	533.40[a]	1.63[a]
62-26	0.2	0.1	510.51[ab]	1.68[a]
62-27	0.2	0.2	506.58[ab]	1.67[a]
62-24	0.1	0.2	489.91[bc]	1.70[a]
62-25	0.1	0.3	470.50[c]	1.70[a]
62-23	0.1	0.1	465.58[c]	1.71[a]

[1]Composition and calculated analysis given in Table IV.

[2]Means with different superscripts are significantly different at the 1% level of probability as calculated by Duncan's Multiple Range Test (1955).

TABLE XIV

ADJUSTED AVERAGE BODY WEIGHTS AND FEED CONVERSION RATIOS OF CHICKS AT FOUR WEEKS OF AGE
EXPERIMENT III

Diet number[1]	Supplemental amino acids in the diet		Average body weights[2]	Feed/weight[2]
	L-lysine	DL-methionine		
	Percent		Grams	
62-33	(soybean oil meal, control)		545.59[a]	1.65[a]
62-31	0.15	0.2	507.68[ab]	1.70[a]
62-32	0.2	0.2	499.82[b]	1.73[a]
62-30	0.1	0.2	485.82[b]	1.73[a]
62-29	0.05	0.2	444.89[c]	1.88[a]

[1]Composition and calculated analysis given in Table V.

[2]Means with different superscripts are significantly different at the 1% level of probability as calculated by Duncan's Multiple Range Test (1955).

62-29 (0.05 percent lysine and 0.2 percent methionine) was statistically different and the lowest of all chicks weights secured. Diet 62-23 (soybean oil meal control) produced chicks with the largest average body weight which was significantly different from the average body weight of chicks fed diets 62-29 (0.05 percent lysine and 0.2 percent methionine), 62-30 (0.1 percent lysine and 0.2 percent methionine), and 62-32 (0.2 percent lysine and 0.2 percent methionine) but was not different from the average body weight of chicks fed diet 62-31 (0.15 percent lysine and 0.2 percent methionine). These differences were significant at the 1 percent level of probability. At the 5 percent level of probability there was no significant difference in average body weights between birds fed diets 62-30, 62-31 and 62-32. However, the birds fed the diet 62-33 (soybean oil meal, control) and diet 62-29 had the largest and smallest average body weights, respectively, which were statistically different from the other diets used. There was no statistical difference in the feed conversion ratios for chicks fed the five experimental diets.

Experiment IV. The results of this experiment are summarized in Table XV. At the 5 percent level of probability there was no difference in average body weights between chicks fed diets 62-34 (soybean oil meal, control), 62-36 (0.2 percent lysine and 0.2 percent methionine), and diet 62-39 (0.2 percent lysine and 0.5 percent methionine). Similarly, there was no difference in body weights of chicks fed diet 62-35 (0.2 percent lysine and

TABLE XV

ADJUSTED AVERAGE BODY WEIGHTS AND FEED CONVERSION RATIOS OF CHICKS AT FOUR WEEKS OF AGE
EXPERIMENT IV

Diet number[1]	Supplemental amino acids in the diet		Average body weights[2]	Feed/weight[2]
	L-lysine	DL-methionine		
	Percent		Grams	
62-34	(soybean oil meal, control)		555.42[a]	1.52[a]
62-39	0.2	0.5	549.02[a]	1.52[a]
62-36	0.2	0.2	533.52[ab]	1.55[a]
62-37	0.2	0.3	520.62[ab]	1.62[ab]
62-35	0.2	0.0	510.22[b]	1.76[b]
62-38	0.2	0.4	505.32[b]	1.52[a]

[1]Composition and calculated analysis given in Table VI.

[2]Means with different superscripts are significantly different at the 1% level of probability as calculated by Duncan's Multiple Range Test (1955).

0.0 percent methionine), 62-36 (0.2 percent lysine and 0.2 percent methionine), 62-37 (0.2 percent lysine and 0.3 percent methionine), and 62-38 (0.2 percent lysine and 0.4 percent methionine). Diets 62-34 (soybean oil meal control) and 62-39 produced the largest average body weights which were significantly different from that produced by diet 62-38 (0.2 percent lysine and 0.4 percent methionine), and diet 62-35 (0.2 percent lysine and 0.0 percent methionine).

At the 1 percent level of probability there was no significant difference in body weights of chicks fed diets 62-34, 62-36, 62-37 and 62-39. Chicks fed diets 62-35, 62-36, 62-37 and 62-38 were also similar in average body weights.

The feed efficiency of birds fed diets 62-34, 62-36, 62-37, 62-38 and 62-39 were not different statistically. Chicks fed diet 62-35 had the poorest feed conversion ratios while chicks fed diets 62-34, 62-36, 62-38 and 62-39 possessed the best. These differences were significant at both the 5 and 1 percent levels of probability.

Experiment V. The results of this experiment are summarized in Table XVI. Chicks fed diets 62-40 (soybean oil meal control), 62-42 (0.4 percent lysine and 0.2 percent methionine), and 62-44 (0.4 percent lysine and 0.6 percent methionine) had similar body weights. Diets 62-41 (0.4 percent lysine and 0.0 methionine), 62-42 (0.4 percent lysine and 0.2 percent methionine), 62-43 (0.4 percent lysine and 0.4 percent methionine), and 62-44 (0.4 percent lysine and 0.6 percent methionine) produced chicks with

TABLE XVI

ADJUSTED AVERAGE BODY WEIGHTS AND FEED CONVERSION RATIOS OF CHICKS AT FOUR WEEKS OF AGE
EXPERIMENT V

Diet number[1]	Supplemental amino acids in the diet		Average body weights[2]	Feed/weight[2]
	L-lysine	DL-methionine		
	Percent		Grams	
62-40	(soybean oil meal, control)		560.2[a]	1.55[a]
62-42	0.4	0.2	546.0[a]	1.56[a]
62-44	0.4	0.6	540.4[a]	1.56[a]
62-41	0.4	0.0	524.3[a]	1.62[a]
62-43	0.4	0.4	523.5[a]	1.66[a]

[1]Composition and calculated analysis given in Table VII.

[2]Means with different superscripts are significantly different at the 1% level of probability as calculated by Duncan's Multiple Range Test (1955).

similar body weights. Diet 62-40 (soybean oil meal control) produced the largest weights and diets 62-41 and 62-43 the smallest. These differences were significant at the 5 percent level of probability. At the 1 percent level of probability there was no difference between the five treatment levels.

Feed efficiency followed similar trends at both levels of probability.

Floor Studies

Experiment VI. This experiment was conducted in floor pens. The results are summarized in Table XVII. Chicks fed diets BR-17 (0.15 percent lysine and 0.2 percent methionine) and BR-18 (0.2 percent lysine and 0.2 percent methionine) had body weights which were not significantly different from one another but the birds were significantly lighter than those fed diets BR-19 (0.2 percent lysine and 0.4 percent methionine), BR-20 (0.4 percent lysine and 0.4 percent methionine), and BR-16 (soybean oil meal, control). Birds fed diets BR-19, BR-20 and BR-16, however, did not differ significantly from one another in body weights. Where significant differences were noted they were significant at both the 5 and 1 percent levels of probability. At the 5 percent level of probability the feed efficiency of chicks fed diets BR-20 was better and significantly different from those on BR-17, 18 and 19. The feed conversion ratios of chicks on diets BR-16, BR-18 and BR-19 were not statistically different from one another. Similarly, feed efficiency of chicks

TABLE XVII

AVERAGE BODY WEIGHTS AND FEED CONVERSION RATIOS OF CHICKS AT EIGHT WEEKS OF AGE
EXPERIMENT VI

Diet number[1]	Supplemental amino acids in the diet		Average body weights[2]	Feed/weight[2]
	L-lysine	DL-methionine		
	Percent		Ounces	
BR-20	0.40	0.40	48.61[a]	2.06[a]
BR-16	(soybean oil meal, control)		48.24[a]	2.08[ab]
BR-19	0.20	0.40	48.02[a]	2.10[ab]
BR-18	0.20	0.20	47.00[b]	2.11[ab]
BR-17	0.15	0.20	46.93[b]	2.13[b]

[1]Composition and calculated analysis given in Table VIII.

[2]Means with different superscripts are significantly different at the 1 percent level of probability as calculated by Duncan's Multiple Range Test (1955).

on BR-17, BR-18 and BR-19 was not significantly different from one another. At the 1 percent level of probability chicks on diet BR-20 had the best feed conversion ratio which was statistically different from those on diet BR-17. The feed efficiency of chicks fed diets BR-16, BR-18, BR-19 and BR-20 was not significantly different from one another. Birds fed diets BR-16, BR-17, BR-18 and BR-19 also had similar feed efficiency ratios.

The weekly average body weights and feed consumption data are summarized in Tables XVIII and XIX. The average weekly weights of chicks fed diets 16 and 20 were consistently greater than those fed the other diets, while those fed diet 17 had the smallest average body weights. Chicks fed diet 18 were almost as heavy as those fed diets 16 and 20 except when they were weighed at the eighth week. The chicks fed diet 18 had the lowest feed consumption during both the seventh and eighth weeks.

Layer Diet Studies

Experiment VII. The results of this experiment are summarized in Table XX. The percent egg production of hens receiving the control diet or the peanut meal diets, regardless of amino acid supplementation, ranged from 56.98 to 58.85 percent. No significant differences in egg production were found between treatments. Pullets on diet EL-30 produced the largest eggs and those on EL-31 the smallest. Diet EL-31 gave the best feed conversion ratios and diet EL-30 the poorest. The average weights

TABLE XVIII

AVERAGE BODY WEIGHTS OF CHICKS BY WEEKS
EXPERIMENT VI

Diet number	Supplemental amino acids		Weeks							
	L-lysine	DL-methionine	1	2	3	4	5	6	7	8
	Percent		Grams							
BR-16	(soybean oil meal, control)		96	200	338	504	700	882	1102	1369
BR-17	0.15	0.2	87	184	323	489	678	844	1063	1332
BR-18	0.2	0.2	90	194	334	504	689	880	1102	1334
BR-19	0.2	0.4	89	192	331	496	691	866	1080	1363
BR-20	0.4	0.4	92	197	337	505	687	886	1109	1379

TABLE XIX

AVERAGE FEED CONSUMPTION PER CHICK BY WEEKS
EXPERIMENT VI

Diet number	Supplemental amino acids		Weeks							
	L-lysine	DL-methionine	1	2	3	4	5	6	7	8
	Percent		Pounds							
BR-16	(soybean oil meal, control)		.158	.385	.577	.722	.876	.907	1.176	1.437
BR-17	0.15	0.2	.151	.378	.560	.725	.874	.903	1.187	1.458
BR-18	0.2	0.2	.163	.387	.569	.733	.863	.937	1.139	1.383
BR-19	0.2	0.4	.161	.390	.563	.733	.896	.894	1.154	1.465
BR-20	0.4	0.4	.155	.373	.553	.736	.863	.959	1.151	1.463

TABLE XX

SUMMARY OF THE RESPONSE OF LAYERS TO LYSINE AND METHIONINE SUPPLEMENTATION IN A CORN-FISH MEAL-PEANUT MEAL DIET

Diet number	Supplemental amino acids		Average production	Average egg weight	Feed efficiency	Average increase in body weight
	L-lysine	DL-methionine				
	Percent		Percent	Ounces/doz.	Pounds/doz.	Ounces
LR-1	(soybean oil meal, control)		56.98	25.35	5.40	9.1
EL-29	0.0	0.0	58.19	25.45	5.24	6.7
EL-30	0.29	0.0	57.41	25.61	5.47	7.3
EL-31	0.29	0.06	58.85	25.27	5.15	7.5

of birds on the different diets showed an increase at the end of the experimental period. Diet LR-1 showed the highest increase and diet EL-29 the lowest.

The laying house mortality was very low during the experimental period. Birds fed diets LR-1 and EL-29 had the lowest mortality and diet EL-31 had the highest. The mortality during the experimental period was 3.06 percent, none of which could be attributed to dietary treatments.

None of these differences in laying house performance was statistically different.

DISCUSSION

Broiler Diet Studies

In the following discussion all comparisons with published material have been made after converting the reported data to a 25 percent protein basis. For example, the National Research Council (1960) suggests a 1.0 percent lysine level in a diet containing 20 percent protein; on conversion to a 25 percent protein basis this would be 1.25 percent.

Table XXI gives a summary of the adjusted average body weights of chicks fed the different diets used in all the battery experiments.

Chicks fed a diet containing peanut meal with no added lysine and 0.2 percent methionine had a significantly lighter average body weight than did chicks fed a soybean oil meal diet ($P<0.1$). When 0.05 percent lysine was added to such a diet, the growth rate was still lower than that of chicks fed the soybean oil meal diet ($P<0.1$); which indicated that the level of lysine supplementation was insufficient to produce optimum growth. The calculated levels of lysine and total sulphur amino acids in this diet were 0.9 and 1.0 percent, respectively. Blaylock and Richardson (1950) reported optimum growth rate of chicks fed a milo-peanut meal diet supplemented with 0.2 percent L-lysine to raise the dietary lysine to 0.91 percent. The results of this experiment are, however, not in agreement although the

TABLE XXI

SUMMARY OF ADJUSTED AVERAGE BODY WEIGHTS IN GRAMS OF FIVE BATTERY EXPERIMENTS WITH DIFFERENT LEVELS OF SUPPLEMENTAL AMINO ACIDS[1]

Percent added lysine, peanut meal diets	Percent added methionine in peanut meal diets													
	Experiment number													
	1	2			3	4					5			
	0.2	0.1	0.2	0.3	0.2	0.0	0.2	0.3	0.4	0.5	0.0	0.2	0.4	0.6
0.00	488[b]													
0.05					445[c]									
0.10		466[c]	490[bc]	471[c]	486[b]									
0.15					508[ab]									
0.20	566[a]	511[ab]	507[ab]	533[a]	500[b]	510[b]	534[ab]	521[ab]	505[b]	549[a]				
0.30	550[a]													
0.40	549[a]										524[a]	546[a]	524[a]	540[a]
0.50	575[a]													
Control diet[2]	579[a]				546[a]	555[a]					560[a]			

[1]Means having different superscripts are significantly different at the 1% level of probability calculated by Duncan's Multiple Range Test (1955).

[2]The average body weights of chicks fed soybean oil meal control diets have been placed in the first column of each experiment irrespective of column headings.

levels of lysine in the two diets are almost similar.

When the supplemental lysine level was further increased to 0.15 percent of the diet, the body weights of the chicks did not differ from that of the controls ($P < 0.1$). This gave an indication that, in the type of diet used, 0.15 percent added lysine may be the minimum level to support optimum growth. However, there was a difference of about 50 grams in the average body weights of the two treatment groups.

When the supplementary level of lysine was kept constant at 0.1 percent and the methionine added at 0.1, 0.2 and 0.3 percent levels, no significant difference in body weight was found, but chicks fed the 0.1 percent added level of methionine had the lightest body weights and the chicks fed the 0.2 percent level the heaviest.

When the level of added lysine in the diet was 0.2 percent and the methionine 0.2 percent, it was interesting to note that in two of the three experiments which had soybean oil meal diets as controls, the chicks did not differ significantly in body weights from the controls ($P < 0.1$) The calculated analysis of this diet showed that it contained 1.04 and 0.99 percent lysine and total sulphur amino acids, respectively. This may be an indication that 0.2 percent level of lysine supplementation may be minimal to produce maximum growth. This substantiates the work of Klain et al. (1958) who reported that 1.03 percent dietary lysine produced optimum chick growth. It is, however, not in

agreement with the National Research Council (1960) which recommends 1.25 percent lysine in the diet of the chick. The findings of Almquist (1947), Schwartz et al. (1957) and Anderson (1961) also recommended higher levels of dietary lysine for maximum growth. The level of total sulphur amino acids, however, is in excess of that recommended by Klain et al. (1958), but is closer to the values reported by the National Research Council (1960).

When the diets containing 0.2 percent added lysine were not supplemented with methionine, growth response was poor. There was a trend towards heavier body weights as the methionine level was increased from 0.0 to 0.5 percent of the diet except at the 0.4 percent level. At this level the growth rate response was not equal to that of the groups fed 0.3 or 0.5 percent methionine.

When 0.4 percent lysine was added to the diet and supplemented with graded levels of methionine, the 0.0 and 0.4 percent levels of methionine supplementation did not show as great a failure to respond in growth as when the diets contained only 0.2 percent added lysine. Chicks fed these diets did not differ significantly in body weight from those fed the soybean oil meal control diet ($P < 0.1$), but the differences in body weight were significant at the 5 percent level of probability. This may indicate that the higher level of lysine did have a slight beneficial effect on the growth of chicks fed those diets. The 0.4 percent level of lysine supplementation increased the total

lysine in the diet to 1.24 percent, thus supporting the findings of Schwartz et al. (1957) and the National Research Council (1960) who recommended 1.26 and 1.25 percent lysine, respectively, in the diet of chicks for optimum growth. It is lower than the recommendation of Anderson (1961) and higher than the values obtained by Blaylock and Richardson (1950), Almquist (1947) and Klain et al. (1958).

On the basis of the battery experiments, 0.2 percent lysine and 0.2 percent methionine were considered to be the minimum supplementation levels for optimum growth. However, there was an indication that higher levels of supplementation might have a beneficial influence on growth. In the floor pen experiments the 0.15 and 0.2 percent lysine supplemented diets containing 0.2 percent added methionine produced significantly lighter body weights than diets containing 0.2 and 0.4 percent lysine supplemented with 0.4 percent methionine as well as the soybean oil meal controls. However, the chicks fed diets containing 0.2 percent lysine and 0.2 percent methionine showed as good growth as the chicks on the control diet until 7 weeks of age (Table XVIII). Feed consumption of this group seemed to be low during the seventh and eighth weeks. No explanation of this situation is attempted. The floor experiments supported the evidence secured from the battery experiments in that supplementing the peanut meal diet with 0.4 percent lysine to increase the dietary level to 1.24 percent did have a beneficial effect

on growth rate. The 0.4 percent level of methionine supplementation raised the dietary level of total sulphur amino acids to 1.11 percent which is higher than the levels recommended by Klain et al. (1958) and Anderson (1961). It is, however, more in agreement with the findings of Almquist (1947), Blaylock and Richardson (1950), Milligan et al.(1951) and the National Research Council (1960). While many of the supplemented peanut meal diets fed in the battery experiments produced average chick weights which did not differ significantly from the weights of chicks fed the soybean oil meal control diets, at no time were the average body weights of any of the chicks fed the peanut meal diet numerically equal to the weights of the chicks fed the soybean oil meal diets. This effect was not observed in the floor experiments.

Although these experiments were not designed to determine whether lysine or methionine was the first limiting amino acid for growth, a comparison of the response of chicks fed supplemental levels of lysine, indicates that lysine is possibly the first limiting amino acid. In Experiment I, the peanut meal diet containing no added lysine and 0.2 percent added methionine produced growth gains equivalent to only 84.3 percent of the control soybean oil meal diets; whereas, when 0.2 and 0.4 percent lysine was added to the diets containing no added methionine, the response was 91.8 and 93.5 percent, respectively, of the controls.

Feed efficiency, in general, tended to follow the same

pattern as average body weights when the peanut meal diets were supplemented with 0.2 percent methionine and graded levels of lysine. When 0.1 and 0.2 percent lysine were added to peanut meal diets and each of these in turn was supplemented with graded levels of methionine, the diets containing 0.2 percent of added lysine tended to give better feed conversion values. These results were, however, not statistically significant. Chicks fed diets containing 0.2 percent lysine and 0.4 percent methionine had poor body weights, but had the same feed conversion ratios as those fed the soybean oil meal diets ($P < 0.1$). At the 0.4 percent level of added lysine and graded levels of methionine, the chicks had the same feed efficiency as the chicks on the soybean oil meal diets ($P < 0.1$). When chicks were grown in floor pens, the 0.4 percent lysine with 0.4 percent methionine supplementation levels produced significantly better ($P < 0.1$) feed efficiency than the 0.15 percent lysine and 0.2 percent methionine supplementation levels.

Layer Diet Studies

No significant difference was found in the laying house performance of pullets fed unsupplemented peanut meal diets as compared to the soybean oil meal control diets. A comparative study of the two diets (Table VII) showed that the soybean oil meal diet (LR-1) contained, on a calculated analysis basis, 0.88 percent lysine and a total of 0.61 percent sulphur amino acids

and the peanut meal diet (EL-29), 0.59 percent lysine and 0.57 percent total sulphur amino acids. The National Research Council's (1960) recommendation for lysine and total sulphur amino acids in the diet of the layer is 0.58 percent and 0.62 percent, respectively, for diets containing 17.5 percent protein. Hence, on a calculated basis diet EL-29 is only slightly deficient in total sulphur amino acids but meets the lysine requirement. The findings of Leong and McGinnis (1952) and Ingram et al. (1951a,b) also indicate that EL-29 is not deficient in these amino acids. The results of this experiment are also in agreement with Dearstyne et al. (1940).

As layers fed EL-29 showed a gain in body weight at the end of the experimental period with no statistical differences in laying house performance, it may be inferred that a corn-fish meal-peanut meal diet of the kind used in this experiment does not require a supplementation of amino acids for satisfactory laying house performance.

SUMMARY AND CONCLUSIONS

A total of 3260 commercial broiler type chicks were used in six experiments to study the levels of supplementary lysine and methionine required in a corn-fish meal-peanut meal diet for optimum growth and feed conversion.

Diets containing 0.2 percent added lysine with 0.2 percent added methionine seemed to satisfy the minimum requirement of lysine and methionine to support optimum growth and feed efficiency in battery grown chicks up to 4 weeks of age.

The addition of 0.4 percent lysine seemed to have a beneficial effect on growth rate.

Although diets containing 0.4 percent added methionine depressed growth rate in one battery experiment, higher levels did not show such an effect. This was not observed in the floor experiments. Diets supplemented with either 0.2 or 0.4 percent lysine with 0.4 percent added methionine produced optimum growth of chicks in floor pens.

The data indicate that 0.2 percent lysine and 0.2 percent methionine added to a corn-fish meal-peanut meal diet to give a total of 1.04 percent lysine and 0.58 percent methionine would result in satisfactory growth and feed efficiency of broiler chicks. Evidence indicated that higher levels of supplementation resulted in a beneficial effect on growth rate.

A total of 360 Single Comb White Leghorn-type pullets in wire cages were used to study the supplementary levels of lysine

and methionine necessary for a corn-fish meal-peanut meal type diet. It was found that no supplementation was necessary in such a diet for satisfactory laying house performance.

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