# Supplementation of plant protein with amino acids for broiler production

Dit proefschrift met stellingen van

ISMAIL IBRAHIM AL-AZZAWI

M.Sc. (Animal Nutrition), geboren te Baghdad, Irak, 15 juli 1924,
is goedgekeurd door de promotor: Ir. S. Iwema,
hoogleraar in de leer van de veevoeding.

De Rector Magnificus der Landbouwhogeschool,

IR. W. F. EIJSVOOGEL

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# Supplementation of plant protein with amino acids for broiler production

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**PROEFSCHRIFT**

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IR. W. F. EIJSVOOGEL,
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# Supplementation of plant protein with amino acids for broiler production

**THESIS**

submitted in partial fulfilment of
the requirements for the degree of
doctor of agricultural sciences
at the agricultural university of
Wageningen, Holland
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by

**ISMAIL IBRAHIM AL-AZZAWI**

**B.Sc. (Poultry husbandry) Utah State University**
**M.Sc. (Animal Nutrition) Arizona University**

# THEOREMS

I

It is preferable for the subtropical countries with less favourable environmental conditions to import frozen semen and use the artificial insemination method, than to import alive bulls.

II

In subtropical regions the protein requirements for a human being in summer are higher than those for temperate climate regions.

III

The use of date palm-trees to protect citrus orchards from frost and excessive heat in Iraq, should be replaced by artificial means of crop protection.

IV

The presence of calcium chloride in many saline soils of Iraq prevents alkalization when reclaiming such soils.

V

Expanding agriculture must be accompanied by industrialization to obtain a balance economy in the developing countries.

Agriculture in Economic
Development. 1964 Febr.

VI

N.R.C. fixed requirements of the amino acids for chickens should be revaluated due to the growth rate of the different breeds.

N.R.C. 1960 Publ. 827
Washington, D.C.

VII

Combs' figures MC/P ratio have to be modified according to the protein quality and different energy levels.

Combs 1961.
Nutrition of Pigs and Poultry.

VIII

Digestible protein, rather than crude protein content of the diet should be the true measure for C/P ratio.

IX

The higher digestibility of the animal protein is due to the fact that is has been already passed through another digestive system which regulated the amino acid balance.

X

In the arid subtropical regions the egg production and egg quality of poultry could be improved during hot weather by means of spraying water in combination with artificial ventilation.

I. I. AL-AZZAWI

Wageningen, June 1964.

*To my father*
*and*
*in memory of my mother*

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# INTRODUCTION

The intense demand for production of animal food products of various kinds in the world in order to meet the needs of the rapidly increasing human population, requires careful consideration concerning the various branches of the livestock industry to be given preference.

The fact that for several years the human population of the world has been increasing faster than the production of many animal food products, stresses the urgency of developing more efficient ways to produce more meat in the shortest possible period of time.*

In short what is really needed is the production of more animal food products to provide the people with a better balanced diet containing more protein.

The protein in poultry meat contains essential amino acids which are not found is sufficient quantities in cereal grains, oil seeds, oil seed products, fruits and vegetables.

For that reason it plays a very important role in providing well balanced diets for human consumption.

There is also the aspect of converting feed into food of animal origin, and chickens, in particular broilers, are relatively more efficient than other classes of livestock.**

Broilers consume smaller quantities of feed per unit of gain in body weight than any other meat-producing animal. Moreover, from the stand point of the human consumption they provide a simple and rapid method of producing highgrade white meat. The great attraction of this is the fact that an output of four or in some circumstances five crops of chickens may be attained in one year. This may result in a relatively quick return on the money invested in the enterprise.

The relatively small size of chickens, as compared with cattle, sheep and hogs, and the ease with which the birds adapt themselves to a wide variety of conditions, are some of the factors which could account for the increasing popularity of broiler production in some of the developing areas. The increasing human demand for meat, has been affected by the rising level of consumer purchasing power in some parts of the world, but the broiler industry may fill the gap that has resulted in meat production.

The growing demand for an appealing protein food of good quality is of course accompanied by an increasing need for more knowledge about the protein value.

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* Human protein requirements and their fulfilment in practice proceedings of conference in Princeton, United States, 1955

** Changes in Farm Production and Efficiency. Agricultural Service, Dept. of Agriculture, U.S.A., August 1957.

The protein should be evaluated in terms of the quantity of available amino acids it contains, the nutritional qualities of a protein being determined by the nature and the quantities of constituing amino acids.

The primary purpose of a dietary protein is to provide a pattern of amino acids appropriate for the synthesis of tissue proteins and for other metabolic functions. Thus there exists a need for determining the quantity of each amino acid that is available to the animal. No doubt it will still be convenient for some years at least to use such terms as: "Net protein value, protein efficiency and protein availability", but we should soon stop employing terms such as mentioned above and find instead relatively simple terms for expressing the quantity of the individual amino acids which will be available to a certain animal at a certain age.

Ideally these methods should be chemical ones.

At the present time precise and firm knowledge of the value of the amino acids is only of a limited nature; an illustration of this can be found in a thorough review of the relevant literature, presenting a great range in the values which have been reported, or which can be calculated from reports. On the requirements of methionine and lysine for instance, approximately forty values can be recognized. The reason is that the proteins themselves vary so widely that it will be necessary to consider each protein individually in terms of the specific amino acids which it contributes to the diet in a sufficiently significant amount.

Moreover animal protein concentrates are normally in short supply in the various countries of the world and may usually be rather expensive in other parts. It is for these reasons a very limiting factor in formulating a diet and therefore of importance that they should be used economically.

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## THE SCOPE OF THE STUDY.

The growing population of the world has increased considerably the need for more animal protein. The broiler industry can fill this gap, especially in some of the developing countries. In aiming at an economical level of production, the broiler rations should, in view of the low standard of living, consist as far as possible of feed produced locally. For this reason Iraqi poultrymen are forced to rely on their local products like barley, sesame, millet etc., in formulating a suitable diet.

Because of these limiting factors a non-animal protein diet is being formulated which consists mainly of: barley, corn, millet and sesame meal. An attempt is being made to improve this diet by the addition of free Lysine and Methionine. But due to the fact that proteins vary so widely in amino acid content, it was necessary to study each ingredient and investigate chemically the specific amino acid amounts it contains, in particular lysine and methionine, since those two have been recognized as the first limiting factors in practical poultry diets.

Finally, the main object of this study was to measure the effect of such a diet on growth rate and carcass quality of the broilers.

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## CHAP. I.

## Revue of Literature.

Protein and amino acids.

Proteins are the most important compounds because they are essential to all plant and animal life, since they are components of the active protoplasm of a every living cell.

Plants can synthesize protein by combining the simpler nitrogenous compounds absorbed from the soil and some times from air with water and carbon dioxide. In animals, proteins makeup the principal constituents of the organs and of the soft structures of the body. Animals in general lack the ability of plants to synthesize proteins from simple materials. Therefore they meet their requirements by ingesting proteins from plants or from other animals.

Proteins, although great in number and complex in structure, may all be split by natural or artifical processes into smaller units called amino acids.

It has been reported by Snetsinger (1963) that as many as 90 amino acids have been found in protein. However, about 25 amino acids are at present generally accepted to be products of broken up protein.

All proteins contain the chemical elements carbon, hydrogen, oxygen, and nitrogen. Twelve amino acids contain sulphur but only two of them are important for animal nutrition. A few proteins contain other elements such as phosphorus, iron, iodine and copper.

In (1838), the scientist G. J. Mulder of the Netherlands, introduced the word protein to the scientific literature following a suggestion by the Swedish investigator Berzelius . Mulder had accepted all kinds of albuminous substances as protein, and also considered it to be a complex substance of some heterogeneous organic compounds, e.g. leucine, which was discovered in (1819) by Proust and named as an amino acid by Braconnot in (1820).
Rubner (1897) recognized that proteins of varying origin were not of the same nutritional value and therefore there was no one protein minimum but as many minima as there were proteins.

The general impression was that proteins of plant origin were inferior to those of animal origin for purposes of nutrition, but Osborn (1908) cleared this by his statement that "on chemical grounds there is no more reason for dividing the proteins into two groups of animal and vegetable protein than there is for making a similar distinction between carbohydrates."

McCollum (1910, 1920) showed that protein foods of plant origin contain all the amino acids necessary for the nutrition of an animal, but some of these are, however, present in such limited amounts as to restrict the extent to which the remaining ones, which are more abundant, can be utilized. Finally he stated that for this reason, these proteins are of relatively low biological value, unless supplemented by proteins from other sources, the constitution of which is such as to makeup for their deficiencies. Since then many more important amino acids have been discovered and isolated in protein.

The latest amino acid isolated was threonine by Rose (1938). Abderhalden (1912) had tried to substitute an amino acid mixture for protein, but he did not succeed in this.

Whereas in (1930) Rose and his collaborators did succeed in substituting protein by an amino acid mixture in rat diets. So it was proved that animals can live and grow with amino acids as the only nitrogen source. Animals do in general lack the ability to synthesize certain amino acids. Rose (1938) has termed these "essential amino acids", because they must be present in the diet for normal growth to be maintained. In this respect the made the following classification of amino acids:

Indispensable amino acids (Essential or always required and they must be present in the diet), they are:

Arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine.

Dispensable amino acids (those amino acids that need not be present in the diet), they are:

Alanine, aspartic acid, citrulline, cystine, glutamic acid glycine, hydroxyglutamic, hydroxyproline, norleucine, proline, serine and tyrosine.

But the term "indispensable amino acids" has significance only when qualified as to species and age period of the particular animal. Almquist (1944) outlined briefly a few general facts about amino acid requirement of chicks:

1) The chick has a definite requirement for practically all of the amino acids in building its tissues.
2) Some of the amino acids must be obtained preformed in the diet, while others can be synthesized by the chick, if necessary, from other amino acids.
3) If any one of the amino acids required in the diet is inadequately supplied, the utilization of other amino acids, and of the diet as a whole is correspondingly reduced.
4) If any one of the amino acids is present in a surplus, the excess is not stored, as some vitamins may be, but is quickly destroyed.

This again means inefficient utilization of protein. Also Almquist (1945) gave the dietary amino acid requirements for chicks as below:

| May be absent without detriment to chick. | Required under certain conditions | Required for maintenance and growth |
|---|---|---|
| Alanine | Cystine | Arginiue |
| Aspartic Acid | Glutamic Acid | Histidine |
| Hydroxyproline | Glycine | Isoleucine |
| Serine | Proline | Leucine |
| | Tyrosine | Methionine |
| | | Phenylalanine |
| | | Threonine |
| | | Tryptophan |
| | | Valine |

Hegsted (1941) stated that growing chicks require under certain conditions certain amino acids as: cystine, glutamic acid, glycine, proline and tyrosine, since it was known that the microbial activities in the intestine of the chickens occur on a rather small scale so that synthesis of amino acids could be only very limited.

Rose (1948) proved that methionine can replace all the cystine in the diet, but cystine can replace only a portion of the methionine. Homocystine can replace methionine if the diet contains an ample supply of choline, also phenylalanine can replace tyrosine, but tyrosine can not replace phenylalanine. Moreover the chicken is able to synthesize glycine from acetates.

Almquist (1942) reported that the function of amino acids in chicks are such that methionine and cystine should be considered jointly, since the former can be converted biologically into the latter. Also, he reported that cystine is not required in the diet if there is a sufficient surplus of methionine to meet the requirements for both methionine and cystine.

If cystine is present in the diet, the necessity for the conversion of methionine to cystine is diminished and a lower level of methionine will suffice.

Hegsted (1944) concluded that a diet containing a mixture of amino acids, consisting of leucine, isoleucine, threonine, phenylalanine, valine, methionine, tryptophan, cystine, arginine, lysine, histidine and glycine, as the only substantial source of nitrogen, allows growth in chicks, although much less than a comparable level of adequate protein.

Almquist and Grau (1944) reported that mixtures of 20 amino acids have been used in complete replacement of protein in chick diets. Of these amino acids, alanine, aspartic acid, hydroxyproline, proline, norleucine and serine have been shown to be dispensable.

Almquist (1953) stated clearly that the protein requirement of an animal is actually a requirement of the amino acids which a protein contains. Also Almquist stated that if the quantity of an indispensable amino acid supplied in the diet is not sufficient to allow a maximum rate of growth, the appetite is curtailed and the total synthesis of body protein is reduced.

Titus (1955) concluded that any one of the required amino acids may be a limiting factor in obtaining the maximum gain from a given quantity of feed. An exception is made for glycine, cystine and tyrosine, because the chick can make glycine from creatine and from acetates, and can use methionine in place of cystine, and phenylalanine in place of tyrosine.

Also he mentioned the fact that inasmuch as the quality,or biological value, of a protein depends on the amino acids it contains - which ones and how much of each - it is not enough to specify that a given feed for growing chickens contains a certain quantity of protein. It is desirable to specify that the feed, regardless of whether its protein content is 20 or 23 percent, contains certain minimum quantities of several of the amino acids. An increase in the protein content of the ration increases the percentage requirement of the various essential amino acids as shown for poultry by Almquist (1949) Grau and Kamei (1950), Schwartz, Taylor and Fisher (1953), and Rosenberg and Baldini (1957).

## LEVEL OF NON-ESSENTIAL AMINO ACIDS

Sherman (1959) stated that if the total amount of non-essential amino acids is below the need for building tissue protein, the requirement for essential amino acids is increased. Under these conditions a portion of the essential amino acids is converted into non-essential amino acids. In this connection it should be noted that certain of the non-essential amino acids can be made only by direct conversion from certain of the essential amino acids. The conversion of phenylalanine to tyrosine and methionine to cystine is well established.

Greene (1960) suggested a ration of essential to nonessential nitrogen (E/NE) of 1.7 to 1 as being optimum. In a more extensive study, Stucki and Harper (1961) found that an (E/NE) ratio of 2:1 was best over the nitrogen levels they studied.

## DEFICIENCY OF OTHER NUTRIENTS.

Sherman (1959) concluded that a deficiency of other nutrients in a ration decreases the apparent amino acid requirement. Deficiency of any essential nutrient, vitamin, mineral, or fatty acids results in poor growth and the maximum growth which could be obtained under these conditions would be obtained with a lower level of essential amino acids. A deficiency of vitamin B12, choline or sulfur as sulfate may cause some of the methionine to be used for purposes other than formation of body protein.

Similarly, a deficiency of niacin will cause a portion of the dietary tryptophan to be utilized for niacin synthesis in the body.

Ewing (1963) in his review stated, that it appears that niacin is concerned in the metabolism of many amino acids, probably all of them generally.

Vitamin B-complex deficiency leads to an abnormal or incomplete conversion of tryptophan to niacin and its derivatives. Evidence is building up that many vitamins are closely connected with general amino acid utilization.

Riboflavin bears a definite relation to retention and metabolism of protein. Vitamin C (ascorbic acid) is concerned in metabolism of the amino acids phenylalanine and tyrosine. The folic acid requirement may be related to the level of protein intake. An older and well-known interrelation is that between methionine and choline in which methionine furnishes the methyl group for choline synthesis.

There are various interrelationships between the metabolism of protein or amino acids and various other nutrients, which could have substantial effects upon theoretical requirement figures.

## LYSINE AND METHIONINE

Since the availability of some amino acids in animal protein is better, it was necessary to study the limiting amino acids in plant proteins, as lysine, and methionine.

Lysine was first isolated from a casein hydrolysate by Drechsel (1889) while methionine was isolated also from casein by Mueller (1921). Both lysine and methionine were discovered to be necessary for growth of chicks.

Osborn and Mendel (1914) found that lysine is a limiting factor in chicks growth.

Crystalline lysine was first prepared by Vickery and Leavenworth (1928), while methionine was synthesized by Barger and Coyne in (1928). Fritze and associates (1946) found that lysine is required for normal feather pigmentation and optimum growth of chicks.

March et al. (1950) proved that lysine is the first limiting amino acid and methionine is the second one in plant protein rations. Baldini and Rosenberg (1945), and Carter and Wyne (1958), by their work with turkey poult rations, showed that lysine and methionine are the first and second limiting amino acids, respectively.

The investigations of Milligan (1951) indicate that the lysine level in the ration of the dam influences performance of the young chick.

Klain et al. (1957), from their experiments with four breeds of chicks, concluded that different breeds respond differently to lysine requirements.

Exact quantitative requirements of lysine and methionine for chicks have not been determined accurately since several factors appear to affect the growing chicks' need for these amino acids.

One of the first reports appearing in the literature dealing with lysine requirement of the chicks was that of Almquist and Mecchi (1942), using two synthetic type rations, a Zein diet and an edestin diet, these workers determined that the L-lysine requirement of the young chick (one week old) was 0.9% of the ration.

The results of their work demonstrate a gradual increase in growth as the lysine content of the ration is raised to the optimum level. Jeppeson (1948) found that the lysine requirement is 0.9 percent for chicks at the age of 2 weeks. Graw and Kamei (1950) proved that 1.36 percent of lysine is required for the first 3 weeks of chick growth.

Almquist and Merritt (1950) reported that lysine requirement of four week old chicks is 1.2 percent.

Milligan et al.(1951) found that 1.0 percent of L-lysine and 0.42 percent of methionine during the first six weeks give best growth. Almquist (1952) suggested that between 1.0 and 1.3 percent of lysine is needed in the diet, while he had estimated this in (1942) to be 0.9 percent; he also suggested that 0.45 percent methionine would be enough.

Bird (1953) estimated the requirement for free-lysine to be 0.72 percent of the total ration for the first eight weeks.

The National Research Council (1954) stated that the chick requirement figure for lysien is 0.9 percent. This was applied several years ago on rations which did not produce the rapid rate of growth currently obtainable on commercial rations, but NRC (1961) changed the figure to 1.0 percent lysine.

Edwards et al. (1956) stated that lysine requirement of chicks is related to the rate of growth. With slow growth the requirement, till the sixth week of age, appeared to be 0.9 percent of the diet, and with more rapid growth the requirement appeared to be approximately 1.1 percent of the diet.

Klain et al. (1957) gives the value of 1.15 percent of the diet in the practical diet during the first four weeks.

Also Klain et al. (1958) gave new figures, when more recent results indicated the value of 1.23 percent as lysine requirement of the chicks. Schwartz, Taylor and Fisher (1958) concluded that, up to 4 weeks of age, the chicks require 1.1 percent lysine in a diet containing 20 percent protein of good quality and (975) calories of productive energy per pound of feed, though after that period, the level of lysine could be reduced at a rate of about 0.05 percent per week to a minimum of 0.8 percent. Changes in dietary energy concentration alter the lysine requirement at a rate of 0.07 percent per 100 calories of productive energy. An increase of 3 percent in the protein of the diet, (from 20 to 23 percent) raises the lysine requirement about 0.1 percent of the diet. Also the result of Gartley (1950) and of Kratzer (1955) indicate that the lysine level required in the dietary protein of the chicks is lowered with increasing age of the bird.

Anderson and Dobson (1959) observed that the lysine had not only improved growth when added to diets limited in this amino acid, but that it also appeared to be involved in the chicks' requirement for arginine. Also they presented data which indicate that the chicks requirement for arginine, lysine, and probably other amino acids increase as the level of the other essential amino acids found in the diet in balanced proportions increase.

Combs et al. (1959) concluded that the addition of methionine, 0.5 percent to start and 0.4 percent to finishing broilers rations to meet the NRC requirement, resulted in an improvement in both average weights and feed conversion.

Baldini and Rosenberg (1955) demonstrated convincingly that the methionine requirement of the growing chick expressed as a percentage of the diet, was directly related to the energy content of the diet.

In a review presented by Hill (1953); he stated that forty values estimated for methionine and lysine requirement, ranged from 0.28 to 1.2 percent for methionine, while the L*-lysine values range was from 0.25 to 1.56 percent. The levels given by Sherman (1959) in table (1) are the ones usually used as requirements of the various species and, although they are subject to change as additional information is obtained, they are of considerable value in assessing the rations of the various amino acids required by the different species.

TABLE 1.

Amino acids requirement of various species.

| Amino Acids | Man** | Chicken | Turkey | Pig | Dog | Rat |
|---|---|---|---|---|---|---|
| Lysine | 0.20 | 0.9 | 1.5 | 1.00 | 0.19 | 1.0 |
| Arginine | 0.0 | 1.2 | 1.6 | 0.20 | 0.19 | 0.2 |
| Histidine | 0.0 | 0.15 | ? | 0.40 | 0.19 | 0.4 |
| Isoleucine | 0.18 | 0.6 | 0.84 | 0.70 | 0.52 | 0.5 |
| Leucine | 0.28 | 1.4 | ? | 0.80 | 0.56 | 0.9 |
| Methionine*** | 0.28 | 0.8 | 0.87 | 0.60 | 0.22 | 0.6 |
| Phenylalanine**** | 0.28 | 1.6 | ? | 0.46 | 0.37 | 0.7 |
| Threonine | 0.13 | 0.6 | ? | 0.40 | 0.26 | 0.6 |
| Tryptophane | 0.06 | 0.2 | 0.26 | 0.20 | 0.15 | 0.2 |
| Valine | 0.20 | 0.8 | ? | 0.40 | 0.56 | 0.7 |
| Glycine | - | 1.0 | ? | - | - | - |

* L-lysine is the active amino acid (Monohydrochloride) or Monochlorhydrate as L-lysine with one molecule each of Hcl and H20 attached. D-lysine is not active.

** Percentages calculated from gm. daily required and daily food consumption.

*** Includes allowance for synthesis of cystine.

**** Includes allowance for synthesis of tyrosine.

In conclusion we can say that a great deal of research has been conducted to estimate the quantitative requirement for the various essential amino acids for the different species of livestock, especially chickens. Much work remains to be done in particular to establish levels for practical application and to investigate the absolute effect of changes in the levels of various other nutrients upon the amino acid requirement.

## ENERGY AND AMINO ACID INTERRELATIONSHIPS.

Combs et al. (1955) stated that, in general, if the energy content of a ration increases, the protein level must also increase.

Almquist (1952) came to the same conclusion. Lewis (1961) suggested to consider not the protein as the unit in nutrition but rather the amino acid. Rosenberg et al. (1955) found that, if the energy level was sufficiently high to permit the protein to be used mainly for tissue synthesis, the amino acid requirement expected to be proportional. Gordon and Maddy (1956) suggested a method of calculating the amount of each essential amino acid required as a percentage of the protein, this based on chick data obtained with methionine additions of diets varying in calori proteins ratio.

An important step forward in understanding this confusing situation was provided by Baldini et al. (1955), who demonstrated convincingly that the methionine requirements of the growing chick, expressed as a percentage of the diet, were directly related to the energy content of the diet. Most data presented by Baldini and Rosenberg (1955) indicate that there is a linear relationship between amino acid requirement, expressed as percent of the diet and energy level. They resulted in a constant value for the ratio of amino acid requirement to energy. There are relatively few other data on the relation of amino acid requirement to dietary energy level, especially on lysine requirement of the chicks. This is what Loosli and Harris (1945) stated, but they concluded that the energy level of the diet appears to affect the lysine requirement of the chicks. Also Hamilton et al. (1948) gave a similar statement about methionine requirement of the chicks.

## ENERGY.

During recent years it has become increasingly clear that the formulation of modern poultry diets requires the use of energy values of feedstuffs in one form or another. Mitchell and Haines (1927 a, b), Fraps and Carlyle (1934 a, b, c, 1941, 1942) have determined respectively the net and productive energy content of several poultry feedstuffs.

Later, making use of the digestibility data and the assumed productive energy values for the effective digestible nutrients in calories per gram, designated as a factor, Fraps (1946) calculated for poultry the productive energy values of feed ingredients from average composition data.

These values have been used extensively during the past decade and were found to be a useful guide for comparing the energy content of feedstuffs. However, experiments conducted more recently by Davidson et al. (1957), Hill and Anderson (1958), indicated that the determined productive energy value of a diet varied considerably from the values calculated with the use of Frap's tables.

There have been some critical comments concerning Frap's procedure and values which he has determined for certain materials.

The metabolizable energy value of several feedstuffs for poultry have been obtained directly by Mitchell and Haines (1927, a, b, 1930), Fraps et al. (1940) Olsson (1950), Halnan (1951).

More recently Hill and Anderson (1955) and Titus (1955) Carpenter and Cleggy (1956) revised the energy value given by Fraps and suggested the use of metabolizable energy values instead of productive energy values, claiming that metabolizable energy values are more easily obtained and are less subject to variation.

Brody (1945) stated that, while the productive energy is reduced by a nutrient deficiency, the metabolizable energy value of the food ingredients is not reduced by this deficiency.

Heuser and Norris (1948) found that as the protein level of a chick starter diet was increased, it was necessary to increase also the dietary energy level and the vitamin content of the diet if the most rapid growth and the most efficient feed conversion were to be obtained.

The studies of Leong et al. (1955), Matterson et al. (1955), Donaldson et al. (1955, 1956, 1957), Lockhart (1955), Ferguson et al. (1956, 1957), showed that in general a definite ratio must be maintained between the percentage of protein and the energy content of the diet. Efficiency of feed conversion was progressively improved as the protein level was increased, provided a corresponding increase was made in the energy level of the diet.

Combs and Romoser (1955) stated that the ratio between productive energy content and the crude protein level of the ration materially influenced feed intake, feed conversion, growth-rate, body composition and feather condition of growing broilers. These workers introduced the term "calorie-protein ratio" (C/P ratio) defined as productive energy (Kcal) per pound (Fraps, 1956) divided by the percentage of crude protein in the ration.

Combs et al. (1955a) concluded that C/P ratios of 43 and 55 were tolerated during the starting and finishing periods, respectively, as measured by effects on growth and feed conversion of "isocalorie" rations. In further studies Combs et al. (1955b) obtained best results with a broiler starting ration with a C/P ratio of 41 and a finishing ration with a C/P ratio of 49.

In recent years metabolizable energy values have largely replaced productive energy value for calculation of energy levels. Accordingly the term C/P is expressed both as a function of productive energy (PC/P) or of metabolizable energy (MC/P).

Due to the studies of Donaldson et al. (1958), Schutze, Thornton and Moreng (1958), Vondell and Ringrose (1958), Marz, Boucher and McCartney (1958), Beilharz and McDonald (1959), Guttridge (1957), Harms, Hochreich and Meyer (1957), Rand, Kummerow and Scott (1957) and Sunde and Bird (1959). Suggested energy-protein ratios for broilers and chicks have been given by Combs (1956).

Suggested calorie-protein ratio*

| | Metabolizable Energy | Productive Energy |
|---|---|---|
| Broiler starter (0 - 5 weeks) | 60 - 65 | 42 - 45 |
| Broiler finisher (after 5 weeks) | 69 - 75 | 48 - 53 |
| Chick starter (0 - 8 weeks) | 63 - 66 | 44 - 46 |
| Chick grower (8 - 18 weeks) | 77 - 86 | 54 - 60 |

* C/P ratio is defined as $\frac{\text{Kcal per lb.}}{\text{\% protein}}$

ENERGY AND FAT.

Roberts (1930) observed that the rate of growth was apparently satisfactory when stearine was fed to chicks at levels of 1 or 2 percent, so that the total fat content by analysis of the feed was 6 or 7 percent. Stearine when fed at a level of 4 percent of the ration apparently retarded growth to some extent. Finally he stated that the calculated fat content according to the analysis of this ration was about 5 percent, exclusive of the stearine, and 9 percent including the stearine. This indicates that the critical point lies somewhere between 7 and 9 percent fat in the ration.

The economical availability of fats for animal feeding made it possible to increase the energy content of poultry rations. Scott et al. (1947) had reported that rations high in energy content promoted more rapid growth and better feed efficiency in chickens than those of lower energy.

Henderson and Irwin (1940) reported that up to (10) percent of soybean oil could be fed to chicks without affecting the rate of growth to eight weeks of age. Greater amounts resulted in deleterious effects. More recent workers, Siedlër and Schweigert, 1953; Sunde, 1954; Runnels, 1954; and Donaldson et al., 1954, reported improvements in feed efficiency but not in growth rate. On the other hand, substantial chick growth improvements were noted by other workers (Robertson et al., 1953; Yacowitz, 1953; Yacowitz and Chambelin, 1954; and Donaldson et al. 1956. Donaldson 1957) demonstrated that less feed was required per unit of gain when energy was added in the form of fat.

With the addition of fat, the requirement of chicks for choline, riboflavin, folic acid and methionine increased, that was the conclusion of(Kummerow et al., 1949; Reiser and Person 1949, Donaldson et al., 1954; and March and Biely, 1954, 1956). Use of fat seemed to lead to a deficiency of some nutrients especially when nutrients were added percentagewise and the feed intake decreased with the rise in energy content of the rations. This led Sunde (1954) to suggest that with fat incorporation, the rations should be reevaluated and the percentage of protein carriers increased. The results of several workers (Yacowitz, 1953; March and Biely, 1954; and Hill and Dansky, 1954), added credence to this statement. Yacowitz (1953) found that increasing the levels of added fat from (2.5) and (5) percent to (10) and (15) percent with protein kept constant, induced signs of protein deficiency such as retarded growth and high incidence of feather picking. Hill and Dansky (1954) lowered the energy level in a low protein diet and restored the chick growth rate.

Biely and March (1954), in their study of relationships between fat and protein levels in chick and poult rations found that the addition of fat to a 19 percent protein diet depressed growth and feed efficiency.

Richardson et al. (1956) in studying the effects of added fat to chick diets suggested that with protein levels of 21.5 percent to 23.5 percent, the optimum calories protein ratio was between (41 and 43).

Gerry, Smith and Howes (1949, 1950), gave the comparative value of high energy-low fiber ration, in regular starting rations. Their results indicate that just as some conventional type rations are better than others, so are some high energy rations better than others.

## ENERGY AND FIBER.

Much research has been conducted on the relation of energy to fiber in chick rations.

Halnan (1930), reported that chicks digested less than (10) percent of the fiber, and that fiber does not contribute to the nutritive value of poultry rations.

Mangold (1934), in following this up, reported that (20 - 30) percent fiber of the grain was digested by poultry.

Robertson (1948) concluded that an (8) percent fiber content in a chick's ration does not reduce the chick's growth.

Later on, Fraps (1946) showed that in general,available energy is correlated with the fiber content of feedstuffs, and that poultry have only a limited ability to digest fiber.

Gerry, Smith and Howes (1949, 1950) found with rations, containing (7,6) percent fiber, poor results in growth and feed efficiency, but they found also that a conventional starter containing (6) percent fiber in some cases has produced growth equal to that obtained with a high energy ration, though feed efficiency was lower.

The studies of, Robertson et al. (1948), Inske and Culton (1949), Panda and Combs (1950), Dansky et al. (1951), Marz et al. (1956, 1957) and Watts and Epps (1958), showed that the various fiber sources gave different results. The addition of fat to the rations improved performance (mainly feed conversion) in all instances but the magnitude of improvement was influenced by the source of fiber. This fact was emphasized by a fat x fiber interaction within the series of rations containing wheat bran and extracted rice bran.

## Cereals, Alfalfa and Sesame Meal.

### Cereals:

Regardless of their apparent nutritional similarity, the cereal grains each show certain peculiarities. Most of the differences in the nutritional value can be found in the protein quality, fiber content and in the mineral and vitamin constituents of the grains. All the cereals are characterized by having a relatively high energy value and a low protein content. Diets consisting primarily of cereals have this characteristically large energy-protein ratio. They should therefore be improved by the addition of proteins.

The National Research Council of Canada (1936) reported that with a supplement of the proper proteins, minerals and vitamins, the cereal grains are about equal in their feeding value for poultry in proportion to their digestible nutrient content or roughly inversely proportional to their fiber content.

Barley shows deficiencies in mineral balance and protein quality, but as compared with yellow corn, Hutton (1931) and Leslie (1933, 1934) reported that barley to be somewhat more efficient for growth than corn. As for rate of growth, Halpin and Hayes (1922) stated that yellow corn is a good source of vitamin A. However Lampman (1936) has found that, unless yellow corn constitutes at least 30 percent of the ration, the vitamin A requirement of chicks will not be met if not some other source for this is provided in the diet, recently Hoffman (1961) stated the B-carotene does not serve as an efficient source of vitamin A, and hence is added evidence for an explanation of the poor response of poultry to natural sources of carotene.

The N.R.C. of Canada (1936) stated that there is little to choose between barley and corn in so far as growth or feed efficiency is concerned, provided the mineral, protein and vitamin deficiencies are corrected by proper supplement. In particular, barley lacks vitamin A as compared with corn. In some samples, the greater fiber content of barley may also be detrimental.

Also barley is as palatable as corn. Hinds (1942) reported that palatability in any of the grains used, barley, corn, and oat was not a factor.

Willsons (1944), tests revealed that when only the gains are considered, corn, wheat and barley have equal feeding value.

Titus (1954, 1961), stated that barley ranks well with corn as an ingredient of finishing diets.

Arscott (1958) stated that performance efficiency data show that barley may replace one-half and three fourths of the ground corn in all rations with results at least comparable to an all corn ration containing no added fat. However, Roman (1958) does not agree with the above result and he stated that the barley should be pearled.

Goodearl (1943) concluded that millet was as acceptable and as readily consumed as yellow corn.

Alfalfa:

Alfalfa leaf meal is an extremely valuable ingredient for chickens, because of its good quality protein and its relative richness in minerals and vitamins, especially vitamin A activity, (carotene), vitamin E and others. Hansen et al. (1953) showed that one to five percent of leaf meal is the level which is usually fed to young chicks; levels higher than 5 percent may cause growth inhibition in some cases, presumably because of the saponin content.

Peterson (1950a) stated that the saponin or saponin-like compound was forming with the cholesterol an insoluble sterol-saponin complex in the digestive tract.

While Newman et aL (1958) confirmed Peterson's finding that Quillaja saponin depressed growth, but they could not confirm the ability of cholesterol to counteract the toxicity of the Quillaja saponin.

Kingsley (1948) found alfalfa to be low in content of sulfur amino acids. Carpenter et al. (1952) and Ellinger (1954) have found that the digestibility of leaf proteins for chicks and rats was reduced by about one-half after drying.

Novak et al. (1953) observed factor (S) in dehydrated alfalfa leaf meal which stimulated growth of the mold, Neurospora-sitophila. In (1958) he proposed to test the growth-stimulating effects of alfalfa.

Janssen (1960) stated that quantity of alfalfa meal to be used in broiler rations depends on the fiber content, also he mentioned that quality fo alfalfa and other grasses depends on the duration between cutting and using.

Sesame meal:

It is well known that sesame is one of the oldest vegetable oil crops cultivated by man; the seed, oil and meal have served as a staple food in the dietary regimen of the Asian people for generations. Sesame has also for centuries been cultivated in Africa, throughout Asia Minor, India, China, Manchuria, Japan and in parts of Europe as has been reported by Altschul (1958).

Titus (1961) concluded that sesame seed meal is a good protein supplement and it is a better source of Arginine, Methionine and Tryptophan than soybean meal, though a poorer source of Lysine, Cystine and Glycine.

Milles (1931), Henk (1943), Hale and Halton (1948) and Baskett et al. (1947) showed that sesame meal is an excellent protein supplement for dairy cattle, beef cattle or sheep and also for poultry or swine, when fed in addition to a lysine-rich supplement. Almquist and Grau (1944) and Patrick (1953) showed that sesame oil meal should be combined with a supplement such as meat scrap, fish meal or soybean oil meal which are rich in lysine.

Table 2 taken from Block and Bolling (1945), will illustrate the essential amino acid composition, of sesame seed protein in comparison with the protein of beef and casein.

TABLE 2.

Amino Acid Analyses of Sesame Seed, Chopped Beef and Casein
(Calculated to 16% nitrogen)

| Amino Acid | Sesame Seed (%) | Chopped Beef (%) | Casein (%) |
|---|---|---|---|
| Arginine | 8.7 | 7.7 | 4.1 |
| Histidine | 1.5 | 2.9 | 2.5 |
| Lysine | 2.8 | 7.2 | 7.5 |
| Tyrosine | 3.5 | 3.4 | 6.4 |
| Tryptophan | 1.8 | 1.3 | 1.2 |
| Phenylalanine | 8.3 | 4.9 | 5.2 |
| Cystine | 1.3 | 1.3 | 0.4 |
| Methionine | 3.1 | 3.3 | 3.5 |
| Threonine | 3.6 | 5.4 | 3.9 |
| Leucine | 7.5 | 7.7 | 12.1 |
| Isoleucine | 4.8 | 3.0 | 6.5 |
| Valine | 5.1 | 3.5 | 7.0 |
| Glycine | 9.3 | --- | --- |

Andros et al. (1949) presented data on the extraction, the processing and the physical and chemical characteristics of oil obtained from white sesame seed. Sesame oil is considered nutritionally equivalent to other edible vegetable fats. Menzes et al. (1949) investigated the properties of the solventextracted oils from four varieties of sesame seed and found only slight variations in the compositions of the oils.

Titus (1961) and Morrison (1956) concluded that sesame meal contains little, if any, vitamin A activity and is not considered a good source of vitamin E. However, riboflavin content of sesame meal is the same as the published values for soybean and cottonseed meal; the average pantothenic acid value tends to be lower.

Jukes (1941), employing a biological assay with chicks, found sesame meal to contain (2.7 mg/lb.) pantothenic acid, but it contains more Niacin (50.4 mg/lb.) than the commonly used oilseed meals, with the exception of peanut meal. Graviato (1945) reported that thiamine content of sesame meal is equal to that of soybean.

Morrison (1951) stated that sesame meal is an excellent source of minerals particularly of calcium and phosphorus.

Lease (1949) gave full data on calcium, phosphorus, manganese, riboflavin, niacin, and pantothenic acid content of screw-pressed sesame meal.

Carcass quality of the chick.

Hammond and associated (1940) showed by their experimental results that the proportions between various parts of the animal body can be modified appreciably by certain methods of feeding, which may be the cause of variation in the quantities of bone, muscle and fat. Clyton (1959) in his work on the evaluation of the quality of poultry carcasses found that the fat content, expressed as percentages of the dry weights of the carcasses, ranged from 11 to 48 percent. The cooked carcasses were tasted and scored by a panel consisting of six persons.

The carcasses were scored for tenderness, juiciness and flavour. The result was that the carcasses with the highest fat content were scored slightly higher than those with the lowest fat contents. However, the difference was not statistically significant.

It has been observed by both Lerner et al. (1947) and Frishknecht and Jull (1946), that the heaviest birds tend to have the highest market grades. The investigations of Donaldson et al. (1956), Arscott and Sather (1958), Essary et al. (1960) and Wagner (1960) showed that a relationship exists between the protein and energy content of the diet and the chemical composition of the flesh of the chicken.

Also they found that as a general rule, when the ration contained less protein in relation to the energy value, the fat content of the carcass increased and the moisture content decreased. The U.S.D.A.* has published (1954) a standard of quality for live poultry on an individual bird basis; the summary of this standard is given in Table No. 3.

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* United States Department of Agriculture.

TABLE No. 3.

U.S.D.A. standard quality

| Conformation | A or No. 1 quality | B or No. 2 quality | C or No. 3 quality |
|---|---|---|---|
| Breast bone | Normal<br>slight curve 1/8* dent<br>thickness 1/4 dent | Practically Normal<br>slightly crooked | Abnormal<br>crooked |
| Back | normal except slight curve | moderately crooked | crooked or hunched back |
| Legs and Wings | normal | slightly misshapen | misshapen |
| Fat covering | well-covered, some fat under skin over entire carcass | enough fat on breast and legs to prevent a distinct appearance of flesh through skin | lacking in back and thighs, small amount in feather tract |
| Fleshing | well fleshed moderately broad and long breast | fairly well fleshed | poorly developed narrow breast, thin covering of flesh |

* 1/8 inch deep dents.

There are some defects causing undergrades and those are:

1 - procurements bruise (A surface injury to flesh)
2 - breast blisters
3 - poor fleshing
4 - poor bleeding and discoloration
5 - bloody wings.

The U.S.D.A. gave also a good description of a broiler or fryer. The U.S.D.A. defined a broiler or fryer as a young chicken (usually under 16 weeks of age) of either sex, that is tender-meated with a soft pliable, smooth-textured skin and a flexible breast bone cartilage.

The Canadian Department of Agriculture (1960) adopted the same standard of quality as that of U.S.D.A., but as the main defects counted in market grading: crooked keels, breast blisters and incomplete feathering.

However, Hyre (1955) has shown that the tendency towards deformed keels is inherited, although he concluded that the expression of this condition depended on whether the birds were allowed access to roosts during the growing period. Schoffner and Canfield (1957) have reported also that breeds differ in keel defects (crooked keels and breast blisters) in males at the age of six months, while the greatest incidence of these defects occurred in birds reared with roosts.

The Netherlands; carcass grades.

Four tentative grades for dressed poultry have been set up by the slaughtering companies** in the Netherlands. These quality grades are based upon the degree of fleshing, conformation, colour, uniformity and freedom from deformities. And those grades are:

| Grade | Points |
|---|---|
| A | 3.6 - 5.0 |
| B | 2.6 - 3.5 |
| C | 0 - 2.5 |
| Rejects | sick<br>severe injury<br>extreme emaciation<br>crop-bound<br>crippled etc. |

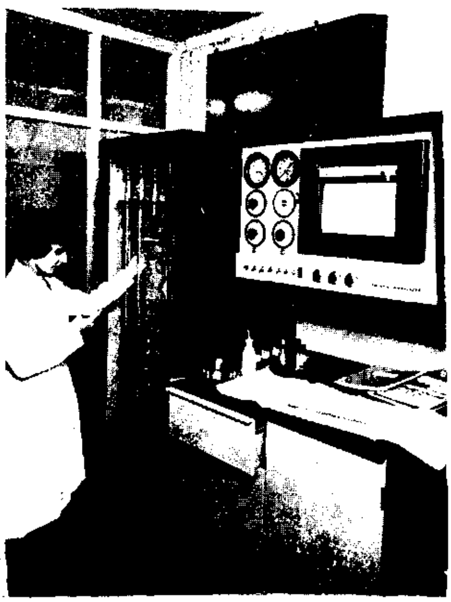

Fig. IA. The automatic amino acid analyzer, with "flowmeter" controlling the flow to exactly 30 ml/hour.

** This based on "Grading Standard" used by Pluimveeslachterij "WEZEP" N.V. Netherlands (1963).

PART. II.

CHAP. II.

## Amino Acids Assay Methods.

Methods of analysis.

The modern methods of chemical analysis which are applied in nutritional research emphasize the amino acids as being the basic factor in all problems where the proteins play a dominant role. During the last twenty years various accurate methods for the determination of amino acids have been developed.

For instance, column chromatography provided a method* for a quantitative analysis of amino acids (except tryptophan), while a microbiological method** is being used to measure the quantity of tryptophan.

### A - Column chromatographical method.

The quantitative determination of amino acids (except tryptophan) for barley, yellow corn, millet, alfalfa meal and sesame meal was carried out by a column chromatography automatic analyzer apparatus. The procedure here discribed was followed for analyzing the samples.

I. All samples were prepared for chromatographic analysis by refluxing with (6 N HCl) for 20-22 hours. This is a common procedure for protein hydrolysis. The resulting hydrolysates were cooled and the acid evaporated in a rotation evaporator under vacuum. The residue was dissolved in water and taken up to 50 ml of water, then it was filtered and conserved with (5 Mg) thymol at $0^{o}C$.

Finally 1 ml is taken for each column (15 cm and 150 cm).

TABLE 4.

Quantities of the ingredients.

| Ingredient | mg. |
|---|---|
| 1. Barley | 148.6 |
| 2. Y. Corn | 750 |
| 3. Millet | 147.7 |
| 4. Sesame Meal | 199.6 |
| 5. Alfalfa Meal | 375 |

* Column chromatograr of the Central Institute for Nutrition and Food Research, T.N.O. Utrecht - Netherlands 1963.

** Analysis been carried out in the same institute (C.I.V.O.) laboratories.

II. <u>The Analysis.</u>

Samples were applied to both columns in the morning (shortly after 9 A.M.). In the preparation of adding the sample to the 15-cm column, several precautions are necessary to prevent contamination by ammonia, the presence of which can give rise to a broad zone underlying the regular ammonia peak on the effluent curve. It was therefore necessary to remove the hall joint and the silicon washer from the top of the long column and to wipe the hall and the socket with a moist cloth to remove any ammonium salts that may have been deposited from the atmosphere. The joint was placed (usually bent at a 60° angle) over the edge of a 30-ml beaker, just rinsed with distilled water, and pump 2 turned on for a few minutes to add about 1 ml of buffer to the beaker. Then the buffer was withdrawn from above the resin surface with the aid of a wiped pipet and added to the beaker.

After this the sample of the amino acid solution which was to be analyzed (at about Ph 2) was added with a calibrated bent-tip pipet to the surface of the resin which is just clear of the free liquid. The volume of the sample applied was usually 2 ml.

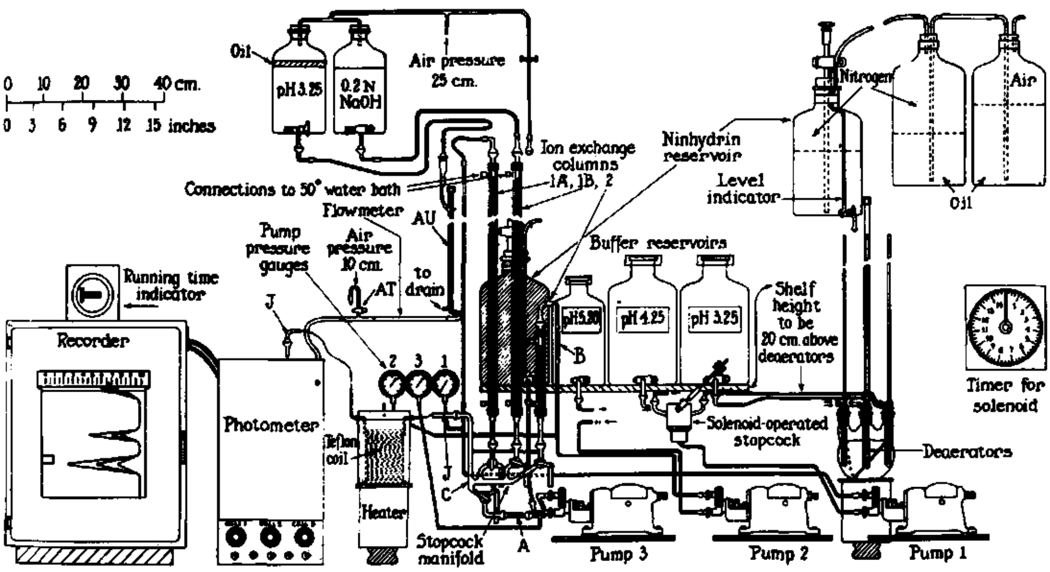

**Figure 1. Automatic recording apparatus used in chromatographic analysis of mixtures of amino acids**

The short column which has been equilibrated with Ph 3.25 buffer overnight is been prepared for this sample by pipetting out or aspirating off the buffer from above the resin.

When a 2-ml sample (at Ph 2) was applied, an air pressure of 5 lbs/Sq. in ( 25 cm of mercury = 25 cm of mercury/Sq. Cm.= 0.33 atm.) was used to drive it in. (15 to 20 minutes are required to drive the sample almost completely into the resin).

While the sample is passing into the long column, the addition to the short column was completed in 3 to 4 minutes, by applying air pressure.

The sample was washed with three 0.2-ml aliquots of the PH 5.28 buffer taken from the beaker by using a bent-tip micropipet which makes it easier to rinse down the walls of the tube thoroughly. To replace the sodium acetate buffer above the resin, the same pipet (bent-tipped) was used with which it was withdrawn. Also the silicon washer was replaced with the aid of forceps, taking care to center it and attache the buffer line to pump 2. Before the pump of the 15 cm column was started, the rate of flow of buffer alone was checked (from pump 1) which had been pumping buffer through the column and the coil for about 30 minutes to show a rate of 30 $\pm$ 0.2 ml per hour. After this measurement of rate of flow the stop cock of the long column (1B) from the recorder was turned on and then pump I was switched off. Pump 2 was started, and the stop cock of column 2 turned to the recorder position, the interval timer had been set for 20 minutes as the time required for the forerun of the short column.

During the forerun of column (2), the addition of the sample to the long column (1A) had been completed. The sample was washed with three 0.2 ml aliquots of PH 3.25 sodium acetate buffer, filling the space above the resin with the PH 3.25 sodium acetate buffer. Then the buffer line leading from pump I was transferred from the used column (1B) to column (1A), two clamps were used for the connection.

Then pump (I) was swithced on and the timer (I) was set for 20 minutes to time the forerun, which in this case takes places with the effluent directed to the drain.

Pump (I) was turned off when timer I started to ring and remained turned off until the time the chromatogram was starting to register. While the forerun on column 2 was proceeding, there was usually also time to apply the 0.2N sodium hydroxide wash to the used 150 cm columns (1B).

The buffer was pipeted out to within 2 cm of the surface of the resin and the tube was filled with sodium hydroxide and attached to the ball joint from the reservoir. Then the stopcock or clamp was opened and the alkali was allowed to enter the column under 5 lbs/Sq. in pressure during the day.

III - <u>Recording from column 2.</u>

When timer 2 rang after 20 minutes, the running time meter was switched on, and pump 3 (ninhydrin) was also switched on and the ninhydrin stopcock was turned from the drain to the recording position.

Timer 2 was set for (39) minutes as a reminder that after 40 minutes the running time indicator and the recorder had to be switched on. The chart paper was adjusted so that the instrument should print on one of the heavy horizontal lines. The effluent volume is 20 ml at this time and the chart can be

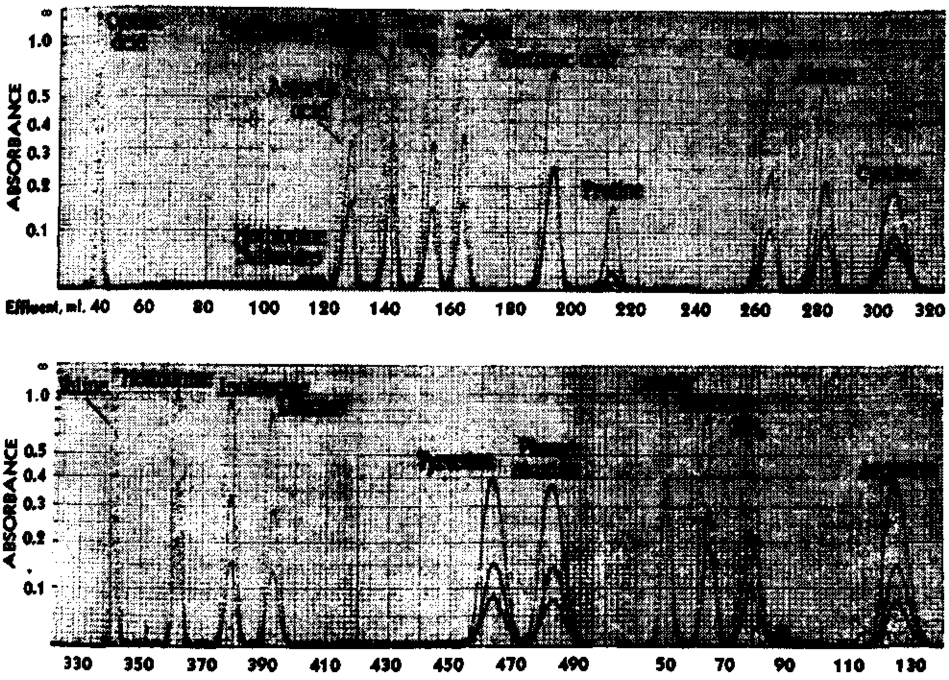


**Figure 2. Chromatographic analysis of a mixture of amino acids automatically recorded in 22 hours by equipment shown in Figure 1**

so marked on the margin.

The recorder was adjusted manually after it had been on for at least 2 minutes. The base line of each of the three cells was adjusted to zero by means of the corresponding Helipot and observed for the first few minutes to make sure that the curve has leveled off. Also the combined flow rates of pumps 2 and 3 were measured.

IV - <u>Completion of Analysis on 15-cm column.</u>

The chromatogram is finished after 280 minutes on the running time indicator (140 ml). The combined flow rate was checked. The recorder was turned off and the chart was advanced mannually about 2 inches. Also the running time indicator was turned off and reset.

Recording from column 1 is the same as mentioned for column 2, but the combined flow rates of pump 1 and 3 should be checked only.

Chromatographic Determination of Cysteic Acid.

The method of Schram, Moore and Bigwood (1954) was used to determine the cystine and cysteic content of the protein, because of the high carbohydrate content of the ingredients.

The determination of the cystine content of proteins is frequently complicated by the unstability of cystine and cysteic acid during protein hydrolysis, particularly in the presence of carbohydrates. Oxidation of the cystine and cysteic residues in the intake protein can convert the amino acids into cysteic acid, which is stable under the conditions of acid hydrolysis.

The method of Schram et al. are based upon this fact, followed by the quantitative determination of cysteic acid by iron-exchange chromatography on columns of Dowex-2. The chromatographic identification of cysteic acid as the end product of the oxidation contributes to the specificity of the method.

V - Calculation.

The calculation method used in this research is the Integration by Height-Times-Width method, where the peaks on the effluent curves are usually integrated by multiplying the height of the peak by the width at the height. This method of integration is rapid and satisfactorily accurate. The height of the peak in absorbance is easily determined from the recorder chart.

In the beginning of the work, the width of each peak on the chart was estimated to 0.1 mm with a ruler graduated to 0.5 mm. As the speedomax multipoint recorder prints a dot every 12 seconds on each curve, the number of dots on the curve above the half-height line can provide an accurate measure of the width of the peak in terms of time (seconds). To facilitate the counting of the dots, every fourth dot is printed in black. The width of a peak can be measured to within one tenth of the distance between dots. So to integrate the peak, the following procedure has been used.

Records are kept on multilithed data sheets ($8\frac{1}{2}$ x 11 inches) that have the following column headings:

1. Amino acid; 2, Base line in absorbance units; 3. Heigth in absorbance units; 4. Half height on chart; 5. Net height, HI; 6. W (width) in dots /12 seconds; 7. H x W; and 8. Micromoles H x W/C; where (C) is a constant for the given amino acid. Several blank columns are included on the sheat for further calculations. First the base line is read to 0.001 absorbance unit. If the curve permits a reading of the actual base line

at both sides of the peak, the average of the two values is used.

For valine which emerges just after the breakthrough of the pH 4.24 buffer, the base line following the peak should be taken. The height of the peak on the chart is then read from the center of the top dot or dots, and noted in column 3. The net height (H, column 5) is obtained by correcting the value in column 3 for the base line. The half-height on the chart (column 4) is determined by taking half of the value in column 5, and adding or substracting the base line correction. Fine lines are drawn to mark the half-height on the ascending and descending sides of the peak. In order to use every fourth black dot as an aid in counting the total number of dots (column 6) the first black dot above the marked line on the ascending side of the curve is skipped and all subsequent, black dots around to mark on the descending side are counted, jotted down and multiplied by 4. The width measurement (W, column 6) is completed by adding to this figure the distance between the penciled lines and the first black dots on the right and the left side of the peak; for the determination these distances of the space between each two individual dots is counted as 1, and the fractional distance from each penciled line to the dot next above is estimated to 0.1 unit. For the final calculations, the net height, H (column 5) of the peak is multiplied by W (column 6). The constant by which H x W is divided to give micromoles of a given amino acid is determined by calibrating the apparatus with a synthetic mixture of amino acids (the constant H x W ($\mu$) mole is a function of the colour yield of the given amino acid in the ninhydrin reaction and the dimensions of the absorption cell).

Table (5)

Summary chart for Amino Acid Constants*

Constant Numbers

| | C** | M.W.*** / H x W |
|---|---|---|
| Alanine | 17.8 | 5.00 |
| Arginine | 18.6 | 9.34 |
| Aspartic Acid | 16.9 | 7.86 |
| Cystine | 16.4 | 7.32 |
| Phenylalanine | 17.9 | 9.24 |
| Glutamic Acid | 17.6 | 8.37 |
| Glycine | 17.6 | 4.25 |
| Histidine | 19.0 | 6.15 |
| Isoleucine | 18.8 | 6.95 |
| Leucine | 18.8 | 6.95 |
| Lysine | 20.9 | 6.90 |
| Methionine | 17.8 | 6.37 |
| Proline | 23.72 | 4.85 |
| Serine | 18.3 | 5.74 |
| Threonine | 17.4 | 6.84 |
| Tyrosine | 18.1 | 10.0 |
| Valine | 18.6 | 6.29 |

* Chart used by the Central Institute for Nutrition and Food Research T.N.O. Utrecht - Netherland. 1963.

** C = Constant

*** M.W. = Molecule Weight.

VI - <u>The Result of the Column Chromatography Analysis Method.</u>

The following values were obtained for the 17 amino acids in Barley, Yellow Corn, Millet, Alfalfa Meal, and Sesame Meal.

TABLE (6).

Total Amino Acid Content of Barley, Corn, Millet, Alfalfa Meal, and Sesame Meal as determined by column chromatography. (calculated to 16 g N).

| | Barley | Y. Corn | Millet | Alfalfa M. | Sesame M. |
|---|---|---|---|---|---|
| Alanine | 4.22 | 7.36 | 10.06 | 4.91 | 4.30 |
| Arginine | 5.57 | 4.73 | 3.54 | 4.61 | 11.81 |
| Aspartic Acid | 6.37 | 6.89 | 6.23 | 10.20 | 7.90 |
| Cystine* | 2.55 | 2.00 | 1.92 | 1.32 | 2.23 |
| Phenylalanine | 5.10 | 4.79 | 5.46 | 4.71 | 4.30 |
| Glutamic Acid | 24.20 | 18.75 | 21.26 | 9.57 | 18.60 |
| Glycine | 4.14 | 3.91 | 2.59 | 4.71 | 4.80 |
| Histidine | 2.23 | 2.92 | 2.01 | 2.01 | 2.20 |
| Isoleucine | 3.66 | 3.50 | 3.93 | 4.02 | 3.50 |
| Leucine | 6.93 | 12.32 | 11.40 | 6.87 | 6.20 |
| Lysine | 3.66 | 2.92 | 1.82 | 5.10 | 2.60 |
| Methionine | 1.67 | 2.22 | 2.68 | 1.47 | 2.60 |
| Proline | 10.11 | 9.29 | 6.61 | 4.46 | 3.50 |
| Serine | 4.14 | 4.56 | 5.75 | 4.12 | 4.10 |
| Threonine | 3.43 | 3.62 | 3.06 | 4.07 | 3.40 |
| Tyrosine | 3.26 | 4.09 | 3.74 | 3.19 | 3.50 |
| Valine | 5.17 | 4.96 | 0.50 | 4.76 | 4.30 |

* Chromatographic Determination of (Cystine) was done separately by using the method employed by E. Schram et al. (1954).

<u>B - Microbiological Method.</u>

It was decided to use the microbiological method in the determination of tryptophan, (because it is destructed more or less on the column) so the Barton-Wright method was applied. The medium of Barton-Wright (1952) was used. The microörganism used was Leuconostoc mesenteroides P - 60 (A.T.C.C. 8042). The culture was obtained from the central Institute for Nutrition and Food Research T.N.O. (C.I.V.O.) Utrecht. The results are shown in Table (7).

TABLE (7).

Total Tryptophan content of Barley, Y. Corn, Millet, Alfalfa Meal and Sesame Meal. Determined by microbiological method.

| | Barley | Y. Corn | Millet | Alfalfa M. | Sesame M. |
|---|---|---|---|---|---|
| Tryptophan | g/16gN | g/16gN | g/16gN | g/16gN | g/16gN |
| quantity | 1.51 | 0.09 | 1.53 | 1.32 | 1.26 |

Experimental Scheme.

The aim was to study the various aspects of the plant protein diet (sesame - corn - barley) for broiler production. The following experiments have been conducted at different intervals and institutes, in order to improve this diet to give optimum growht and feed efficiency, also to study scientifically the interrelationships of various aspects of such a diet.

For this reason the following eight experiments were planned.

Experiment No. 1 - Different high levels of lysine, methionine and energy content.

Experiment No. 2 - Different moderate levels of lysine and methionine with fixed energy level.

Experiment No. 3 - Fixed levels of lysine and methionine plus extra Vit. A, and choline.

Experiment No. 4 - Different levels of digestible protein and energy with fixed levels of lysine and methionine.

Experiment No. 5 - Fixed levels of lysine and methionine plus extra minerals, zinc and sodium.

Experiment No. 6 - Biological determination of the limiting amino acids (lysine, histidine, isoleucine, methionine, threonine, phenylalanine, tryptophan, valine and leucine) in plant protein diet. (for rats).

Experiment No. 7 - Applying the biological determination results on practical broiler diet using glycine and dl-threonine at different levels.

Experiment No. 8 - Applying the biological determination results on practical broiler diet using glycine and l-threonine at different levels.

PART. III.

CHAP. III.

## Materials and Methods.

General Experimental Procedure.

The following procedure was employed in the five following experiments. In each experiment the chicks were assigned at random to each lot. The experimental lots were randomized by chance to the 3 tire electric batteries. Feed water and artifical light were provided continually. All chicks were wing banded. Individual body weights, and feed consumption data were recorded weekly. Room temperatures were recorded daily. Essential amino acid content of all diets was calculated on the basis of the nitrogen content of the ingredients.

The five experiments were conducted at different intervals at the farm of the Central Institute for Poultry Research "Het Spelderholt".

The first experiment took place from 21st March - 9th May 1963, the second experiment from May 23rd - 11th July 1963, the third experiment from 1st August - 19th September 1963, the fourth experiment from 27th of January - 16th of March 1964 and the fifth experiment from 27th of January - 24th of February 1964.

The first four experiments lasted seven weeks, but the fivth one lasted four weeks only. The data obtained from the experiments have been treated statistically.

### Experiment I.

Stock.

Nine hundred and sixty sexed White Cornish and White Plymouth Rocks cross (W.C. x W.Pl.R.) day old chicks were obtained from the Central Institute for Poultry Research "Het Spelderholt" for this experiment. The chicks were wing banded after they had been selected at random for six groups and placed in (48) lots, (24) for each sex with (20) chicks in each lot, as is shown in table (8).

TABLE (8).

Random selection table.

| Group | Male Lot No. | | | | | Female Lot No. | | | |
|---|---|---|---|---|---|---|---|---|---|
| I | 3 | 4 | 29 | 47 | : | 9 | 35 | 39 | 44 |
| II | 20 | 26 | 32 | 45 | : | 17 | 28 | 33 | 37 |
| III | 2 | 11 | 15 | 42 | : | 6 | 13 | 38 | 46 |
| IV | 7 | 19 | 23 | 31 | : | 1 | 22 | 34 | 36 |
| V | 5 | 21 | 24 | 27 | : | 18 | 30 | 40 | 43 |
| VI | 8 | 12 | 14 | 48 | : | 10 | 16 | 25 | 41 |

Management.

For the first 24 hours all chicks received mixture of crashed barley, corn and wheat to clean the digestive system. Feed was provided on paper under the canopy and water also. The quantity of the feed mixture is not fixed (ad libitum). Next morning all chicks were weighed individually and the new feed given to the animals was weighed also.
Temperatures and the mortality rate were recorded daily.

Experimental Diets.

Experiment I was designed to study the value of sesame meal as a main source of vegetable protein, also to study the effect of barley, and millet since they are the most readily available ingredients in Iraq. Iraqi poultrymen rely on sesame meal barley, and millet almost entirely to feed the animals. Also the standard of living will not allow supplementation with animal protein since it is rare and expensive. So it was neceassary to study the possibilities of replacing animal protein by vegetable protein due to the circumstances prevailing in a big part of the world and specially in the Middle East and south east Asia. Opinions on the animal protein factor, or unidentified factors, are still in the theoretical stage only.

Various levels of lysine, methionine, vegetable oil were added to increase caloric density to test their effect on growth rate and carcass quality of the broilers.

The experimental diets differed from the control in two aspects, first, in that no animal protein was added to them whereas it was added to the control. Second, necessary amino acids such as lysine and methionine, were added in different quantities. Lysine preparate levels ranged between 0.45 - 1.83 per cent while the methionine was 0.11 - 0.24 per cent. The energy level was corrected by adding (4-8) per cent more vegetable oil (sesame oil). All diets were supplemented with vitamins ans minerals. Vitamin B12 was added to diets 2, 3, 4, 5 and 6 since no animal protein was added to them. Samples from all rations were analysed and the compositions of the diets were calculated. Details of experimental rations are shown in the following tables.

TABLE (9).

Diets and plan for Experiment I.

| Ingredient | Control(1) | = - 4 weeks | | | | | Control | 4 - 7 weeks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 |
| Barley | -- | 18 | 18 | 18 | 18 | 18 | -- | 22 | 22 | 22 | 22 | 22 |
| Millet | -- | 10 | 10 | 10 | 10 | 10 | -- | 10 | 10 | 10 | 10 | 10 |
| Y-corn | 43 | 30 | 30 | 30 | 30 | 30 | 43 | 30 | 30 | 30 | 30 | 30 |
| Sesame meal | -- | 34 | 34 | 34 | 34 | 34 | -- | 30 | 30 | 30 | 30 | 30 |
| Alfalfa meal | 2 | 5 | 5 | 5 | 5 | 5 | 2 | 5 | 5 | 5 | 5 | 5 |
| Vit A/D3 prep. 2250A/750D3 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 |
| Vital (2) | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Minerals (3) | 2 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 2 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Ca HP04 | -- | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | -- | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| Hydan (4) | 0.1 | -- | -- | 0.11 | 0.11 | 0.19 | 0.1 | -- | -- | 0.16 | 0.16 | 0.24 |
| Lysine prep. (5) | -- | 0.45 | 0.78 | 1.12 | 1.12 | 1.78 | -- | 0.49 | 0.83 | 1.16 | 1.16 | 1.83 |
| Sesame oil | -- | 4 | 4 | 4 | 8 | 8 | -- | 4 | 4 | 4 | 8 | 8 |
| Vit B12 prep. (6) | -- | + | + | + | + | + | -- | + | + | + | + | + |
| Milo | 5 | -- | -- | -- | -- | -- | 5 | -- | -- | -- | -- | -- |
| Oats | 5 | -- | -- | -- | -- | -- | 5 | -- | -- | -- | -- | -- |
| Wheat | 5 | -- | -- | -- | -- | -- | 5 | -- | -- | -- | -- | -- |
| Animal fat | 3 | -- | -- | -- | -- | -- | 3 | -- | -- | -- | -- | -- |
| Soybean meal | 9.5 | -- | -- | -- | -- | -- | 9.5 | -- | -- | -- | -- | -- |
| Sesame cake meal | 3 | -- | -- | -- | -- | -- | 3 | -- | -- | -- | -- | -- |
| Sunflower meal | 3 | -- | -- | -- | -- | -- | 3 | -- | -- | -- | -- | -- |
| Cottonseed meal | 2 | -- | -- | -- | -- | -- | 2 | -- | -- | -- | -- | -- |
| Fish meal (7) | 11 | -- | -- | -- | -- | -- | 11 | -- | -- | -- | -- | -- |
| Meat meal | 2 | -- | -- | -- | -- | -- | 2 | -- | -- | -- | -- | -- |
| Wheypowder | 3 | -- | -- | -- | -- | -- | 3 | -- | -- | -- | -- | -- |
| (8) | 100.22 | 105.47 | 105.80 | 106.25 | 110.25 | 110.99 | 100.22 | 105.47 | 105.80 | 106.25 | 110.25 | 110.99 |

(1) Control diet of Central Institute for Poultry Research "Het Spelderholt", Netherlands
(2) Vital (Riboflavin, pantothenic acid, nicotenic acid, choline, vit. E and K3)
(3) Minerals ($CaCO_3$, $CaHPO_4 \cdot 2H_2O$, NaCl, $CuSO_4 \cdot 5H_2O$, $MnSO_4$, $ZnSO_4$, and KI)
(4) Hydan (Hydroxy analogne of Methionine)
(5) Lysine preparation from France (75% active) L-lysine-HCl
(6) 1 mg in B12 per 100 kg of the ration
(7) Herring Fish meal
(8) Control crude protein = ± 24%
Control Metabolizable energy ± 3200 Cal/kg

TABLE (10).

Calculated Compositions of Experiment I.

| Nutrient | P/kg N.R.C. Rec. (1) | 0–4 week groups | | | | | 4–7 week groups | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 3 | 4 | 5 | 6 | 2 | 3 | 4 | 5 | 6 |
| Crude protein (3) | 20 | +23 | +23 | +23 | +22.5 | +22.5 | +22 | +22 | +22 | +21.5 | +21.5 |
| Dig.protein | -- | +19.5 | +19.5 | +19.5 | +19 | +19 | +18 | +18 | +18 | +17.5 | +17.5 |
| Metabolizable E. Cal/kg. | -- | +2700 | +2700 | +2700 | +2900 | +2900 | +2700 | +2700 | +2700 | +2900 | +2900 |
| Fat | -- | 6.14 | 6.12 | 6.09 | 9.50 | 9.44 | 6.21 | 6.19 | 6.16 | 9.57 | 9.50 |
| Fiber | -- | 6.65 | 6.63 | 6.61 | 6.37 | 6.32 | 6.65 | 6.63 | 6.61 | 6.37 | 6.32 |
| **Amino Acids (%) (2)** | | | | | | | | | | | |
| Lysine | 0.9 | 0.95 | 1.18 | 1.41 | 1.36 | 1.80 | -.95 | 1.18 | 1.41 | 1.36 | 1.80 |
| Methionine + Cystine | 0.8 | 1.07 | 1.07 | 1.17 | 1.12 | 1.11 | 1.00 | 1.00 | 1.15 | 1.11 | 1.17 |
| Arginine | 1.2 | 2.20 | 2.19 | 2.18 | 2.10 | 2.09 | 2.01 | 2.00 | 1.99 | 1.92 | 1.91 |
| Tryptophan | 0.2 | .26 | .26 | .26 | .25 | .25 | .25 | .25 | .25 | .24 | .24 |
| Glycine | 1.0 | 1.02 | 1.02 | 1.01 | .98 | .98 | .96 | .95 | .95 | .92 | .91 |
| Isoleucine | 0.6 | .79 | .79 | .79 | .76 | .76 | .75 | .75 | .74 | .71 | .71 |
| Leucine | 1.4 | 1.67 | 1.66 | 1.65 | 1.59 | 1.58 | 1.58 | 1.58 | 1.57 | 1.51 | 1.50 |
| Phenylanaline + Tyrosine | 1.6 | 1.82 | 1.81 | 1.81 | 1.74 | 1.73 | 1.72 | 1.71 | 1.70 | 1.64 | 1.63 |
| Threonine | 0.6 | .77 | .76 | .76 | .73 | .73 | .72 | .72 | .71 | .69 | .68 |
| Valine | 0.8 | .98 | .97 | .93 | .93 | .93 | .93 | .93 | .92 | .89 | .88 |
| Histidine | 0.15 | .51 | .51 | .51 | .49 | .49 | .48 | .48 | .48 | .46 | .46 |
| **Minerals** | | | | | | | | | | | |
| Calcium % | 1.0 | 1.2 | 1.2 | 1.2 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| Phosphorus % | 0.6 | .81 | .81 | .80 | .77 | .77 | .77 | .76 | .76 | .73 | .73 |
| Sodium % (4) | 0.15 | .20 | .20 | .20 | .19 | .19 | .19 | .19 | .19 | .18 | .18 |
| K % | .20 | .75 | .74 | .74 | .71 | .71 | .65 | .65 | .65 | .62 | .62 |
| Zinc P.P.M. (5) | 20 | 40.07 | 39.94 | 39.77 | 38.33 | 47.28 | 47.14 | 46.94 | 45.23 | 44.53 | 44.53 |

(1) N.R.C. National Research Councils of America, recommended nutrient requirements for chickens (0 – 8) weeks

(2) Please see Chap. II. (Amino acids assay)

(3) From 4 – 7 weeks the protein level was reduced.

(4) Taken from Titus (1961) and Ewing (1963).

(5) Taken from the joint V.S.-Canadian Tables on Feed Consumption, No. 659, National Academy of Science, National Research Council of U.S.A.

TABLE (11).

Calculated Compositions of the Rations of Experiment I.

| Nutrients | 0–4 weeks | | | | | | 4–7 weeks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | N,R.C. | 2 | 3 | 4 | 5 | 6 | 2 | 3 | 4 | 5 | 6 |
| Vitamins | | | | | | | | | | | |
| Vit.A U.S.P.U. P/kg | 2640 | 13136 | 13095 | 13039 | 12566 | 12483 | 13135 | 13094 | 13038 | 12565 | 12482 |
| Riboflavin Mg/kg | 2.86 | 5.43 | 5.40 | 5.40 | 5.20 | 5.16 | 5.37 | 5.35 | 5.33 | 5.13 | 5.10 |
| Pantothenic acid Mg/kg | 9.24 | 11.77 | 11.74 | 11.69 | 11.26 | 11.19 | 11.85 | 11.81 | 11.76 | 11.34 | 11.26 |
| Choline Mg/kg | 1320 | 1137 | 1134 | 1129 | 1089 | 1082 | 1123 | 1122 | 1119 | 1118 | 1105 |
| Niacin Mg/kg | 26.4 | 35.89 | 35.78 | 35.63 | 34.34 | 34.11 | 37.47 | 37.35 | 37.19 | 35.84 | 35.61 |
| Thiamine Mg/kg | 1.76 | 3.72 | 3.71 | 3.70 | 3.56 | 3.54 | 3.78 | 3.77 | 3.75 | 3.62 | 3.59 |
| Vit. B12 | + | + | + | + | + | + | + | + | + | + | + |

TABLE (12).

Average Analyses* of Feed Ingredients used in Experiment I.

| Ingredients | Protein % | Fat % | Ash % | Dry Matter % | Crude Fiber % | N-free Extracted % | Ca % | P % |
|---|---|---|---|---|---|---|---|---|
| Barley | 12.30 | 2.40 | 2.90 | 88.60 | 7.10 | 63.90 | 0.05 | 0.33 |
| Y. Corn | 10.50 | 4.30 | 1.15 | 87.78 | 3.50 | 68.33 | 0.03 | 0.25 |
| Millet | 10.30 | 4.00 | 3.70 | 89.14 | 9.70 | 61.44 | 0.03 | 0.33 |
| Sesame meal | 48.90 | .80 | 10.30 | 88.80 | 7.10 | 21.70 | 2.00 | 1.44 |
| Alfalfa meal | 16.00 | 2.20 | 10.70 | 91.90 | 27.60 | 35.40 | 1.76 | 0.23 |

* Analyses done in Central Institute for Poultry Research Lab. "Het Spelderholt", Beekbergen.
The diets were reanalysed after mixing the rations.

TABLE (13)

Lysine and Methionine Content added to the Rations of Experiment I.

| | Control | 0-4 weeks groups | | | | | Control | 4-7 weeks groups | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 |
| Lysine content of the ration | | .66 | .66 | .66 | .66 | .66 | | .63 | .63 | .63 | .63 | .63 |
| Lysine prep.* added | | .45 | .78 | 1.12 | 1.12 | 1.78 | | .49 | .83 | 1.16 | 1.16 | 1.83 |
| Active lysine added | | .34 | .59 | .84 | .84 | 1.34 | | .37 | .62 | .87 | .87 | 1.37 |
| Total corrected lysine (active) | | .95 | 1.18 | 1.41 | 1.36 | 1.80 | | .95 | 1.18 | 1.41 | 1.36 | 1.80 |
| Methionine + cystine content of the ration | | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 |
| Methionine added | .1 | - | - | .11 | .11 | .19 | .1 | - | - | -16 | .16 | .24 |
| Total corrected methionine | | 1.07 | 1.07 | 1.17 | 1.12 | 1.11 | | 1.00 | 1.00 | 1.15 | 1.11 | 1.17 |

* Lysine preparation, 75% activity.

TABLE (14).

Amino Acid Content of the diets of Experiment I. (0-4) weeks.

| Amino Acids | Barley Y. 18% | Corn 30% | Millet 10% | Alfalfa M. 5% | Sesame M. 34% | Total Amino acids in Diets % |
|---|---|---|---|---|---|---|
| Lysine | 0.08 | 0.09 | 0.02 | 0.04 | 0.43 | 0.66 |
| Methionine | 0.04 | 0.07 | 0.03 | 0.01 | 0.43 | 0.58 |
| Methionine ) | 0.04 | 0.07 | 0.03 | 0.01 | 0.43 | 0.58) 1.13 |
| Cystine ) | 0.06 | 0.09 | 0.02 | 0.01 | 0.37 | 0.55) |
| Arginine | 0.12 | 0.15 | 0.04 | 0.04 | 1.97 | 2.32 |
| Tryptophan | 0.03 | 0.02 | 0.02 | 0.01 | 0.20 | 0.28 |
| Glycine | 0.09 | 0.13 | 0.03 | 0.04 | 0.79 | 1.08 |
| Isoleucine | 0.08 | 0.11 | 0.04 | 0.03 | 0.58 | 0.84 |
| Leucine | 0.15 | 0.41 | 0.11 | 0.06 | 1.03 | 1.76 |
| Phenylalanine | 0.11 | 0.15 | 0.06 | 0.04 | 0.71 | 1.07 |
| Phenylalanine) | 0.11 | 0.15 | 0.06 | 0.04 | 0.71 | 1.07) 1.92 |
| Tyrosine ) | 0.07 | 0.13 | 0.04 | 0.03 | 0.58 | 0.85) |
| Threonine | 0.07 | 0.12 | 0.03 | 0.03 | 0.56 | 0.81 |
| Valine | 0.11 | 0.16 | 0.01 | 0.04 | 0.71 | 1.03 |
| Histidine | 0.05 | 0.09 | 0.02 | 0.02 | 0.36 | 0.54 |

TABLE (15).

Amino Acid Content of the diets of Experiment I. (4-7) weeks.

| Amino Acids | Barley Y 18% | Corn 30% | Millet 10% | Alfalfa M. 5% | Sesame M. 34% | Total Amino acids in Diets % |
|---|---|---|---|---|---|---|
| Lysine | 0.10 | 0.09 | 0.02 | 0.04 | 0.38 | 0.63 |
| Methionine | 0.05 | 0.07 | 0.03 | 0.01 | 0.38 | 0.54 |
| Methionine) | 0.05 | 0.07 | 0.03 | 0.01 | 0.38 | 0.54) 1.06 |
| Cystine ) | 0.07 | 0.09 | 0.02 | 0.01 | 0.33 | 0.52) |
| Arginine | 0.15 | 0.15 | 0.04 | 0.04 | 1.74 | 2.12 |
| Tryptophan | 0.04 | 0.02 | 0.02 | 0.01 | 0.18 | 0.27 |
| Glycine | 0.11 | 0.13 | 0.03 | 0.04 | 0.70 | 1.01 |
| Isoleucine | 0.10 | 0.11 | 0.04 | 0.03 | 0.51 | 0.79 |
| Leucine | 0.19 | 0.41 | 0.11 | 0.06 | 0.90 | 1.67 |
| Phenylalanine | 0.14 | 0.15 | 0.06 | 0.04 | 0.62 | 1.01 |
| Phenylalanine) | 0.14 | 0.15 | 0.06 | 0.04 | 0.62 | 1.01) 1.80 |
| Tyrosine ) | 0.09 | 0.13 | 0.04 | 0.03 | 0.51 | 0.80) |
| Threonine | 0.09 | 0.12 | 0.03 | 0.03 | 0.49 | 0.76 |
| Valine | 0.14 | 0.16 | 0.01 | 0.04 | 0.63 | 1.98 |
| Histidine | 0.06 | 0.09 | 0.02 | 0.02 | 0.32 | 0.51 |

## Result and discussion of Experiment I.

When supplementing plant protein diets with amino acids, there is always the decision to be made as to how much of a particular amino acid should be added. Should the amino acids be added to accept standard level for usual animal protein, or should some other means of decision be employed?

Amino acid requirements are usually established at normal protein levels, and it is generally accepted that amino acid requirements vary, not only with diet energy level but also with protein level.

In experiment I, the levels of added amino acids were based upon the fact that very little is known about the real requirement of the whole plant protein practical diets for broiler production. But it is well known that sesame meal lacks lysine and vitamin B12. For this reason it was designed to chack different levels of lysine and others, as it is given in table (9).

The average 7 weeks weight and feed efficiency (feed consumed over gain) recorded for the (6) groups, with 8 replecations for each group (4 for each sex) for the first experiment are presented in tables (17, 19, 20).

Sesame meal, barley, millet, alfalfa meal and yellow corn were the major ingredients used in the experiment diets, but it was supplemented by different levels of lysine, methionine and vegetable oil (sesame oil).

The result of this experiment showed that applying lysine in different levels did help whole plant protein rations to give almost optimum growth. The approximate quantities of lysine were .95%, 1.18%, 1.41%, 1.36% and 1.8% of the diets, as is shown in table (13). The best growth response was obtained by the females and males of group 3, at alevel of 1.18 per cent lysine only (no methionine was added to this ration), also the males in group 4 gave their maximum growth at 1.41 per cent lysine and approximately 1.17 per cent methionine, and have both $\pm$ 23*, $\pm$ 22** per cent crude protein and $\pm$ 2700 Cal/kg metabolizable energy. From this result we can see clearly that 1.18 per cent lysine alone (with no methionine added) will be enough to satisfy the birds need.

From the above results we can say that 1.18 per cent lysine in (sesame - corn) diet is the best, and this agrees with Almquist (1952) when he suggested that between (1.0 - 1.3) per cent of lysine is needed in the diet for the first 4 weeks. Also it is near the value given by Klain et al. (1957) when

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* 0-4 weeks
** 4-7 weeks

And this agrees with Snetsinger and Scott (1961).

It was almost clear that the female chicks have more response to lysine than males. This fact has been recognized by Shutze et al. (1958) when they stated that the protein requirement for the male bird to eight weeks of age, was greater they mentioned the value of (1.15) per cent lysine in the practical diet during the first four weeks keeping in mind the fact that chicks used in this experiment (and other experiments) are (W.C. x W.P.R)* crossbreds with high rate of growth, we can depend on the statement of Edwards et al. (1956) that the lysine requirement of chicks is related to the rate of growth.

Also the figure 1.1 percent which has been given by Schwartz and Fisher (1958) is applicable, and agrees with the results obtained in this experiment.

A significant improvement in growth resulted from an increase in the level of supplemented lysine from .95 per cent to 1.18 per cent. However, increasing the supplemental lysine respectively from 1.18 per cent to 1.36, 1.41 and 1.80 per cent, was of no benefit for growth, even when the methionine per cent and the energy level were increased, but it did increase the feed efficiency.

In all five rations the crude protein level ± 23 per cent was stable for the first four weeks and then reduced to ± 22 per cent.

Additive vegetable oil to rations 5 and 6 increased the fat content to 9.5 per cent and the metabolizable energy level to 2900 Cal/kg, which helped to produce significant cumulative feed consumption and cumulative feed efficiency, but did not affect growth as shown in table (21). This result agrees with Carew et al. (1961) when they showed clearly that changes in dietary energy level or density from the addition of vegetable oil are not responsible for increases in growth rate and energy intake. Henderson and Irwin (1940) also showed that up to 10 per cent of soybean oil could be fed to chicks without affecting the rate of growth to eight weeks of age. This result agrees with Siedler and Schwigert (1953), Sunde (1954), Runnels (1954) and Donaldson et al. (1954), when they reported that fat improved feed efficiency but not growth. Ans this also agrees with Sunde (1954), when he stated that use of fat seemed, to lead to a deficiency of some nutrients.

Additions of extra lysine and methionine to ration (6) did not show any significant improvement on ration (5), while higher lysine and methionine depressed growth, even when the energy level was increased. Supplementation of methionine not only had no beneficial effect on growth of chicks fed diet supplemented with excess lysine, but actually accentuated the growth depression, improving the feed efficiency only.

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* White Curnish male x White plymouth Rocks female.

than 20 per cent while that for the female was not.

From all the results we can deduce that the difference in weight between chicks fed on an animal protein diet and those fed on a plant protein diet (supplemented with lysine) is not high. But statistical significance is still there, and this can be recognized in tables (22, 23). The mortality rate was very low in all rations as is shoun in table (18).

At the end of the feeding trial of Experiment I, all the birds were sent to the slaughter house (Pluimveeslachterij "WEZEP" N.V.) to be scored and graded according to their commercial carcass quality. The result is given in table (16). From the presented result we can see clearly that in ration 5 and 6 where more vegetable oil was added, better carcass colour and flesh occurred, even if compared to the control itself. This agrees with the results of March and Biely (1954), when they concluded that the ether extract of the carcasses was influenced by the source and amount of energy rather than C/P ratio. Uniformity is changeable in the groups but the average is good. All the groups have been graded equally in the defect item, because all the birds have been reared in batteries where they haveslight breast blsiters, but the six groups were graded as A and B quality and that generally means a high quality meat.

TABLE (16).

Broiler Carceass Quality of Experiment I.

| Groups | I | | II | | III | | IV | | V | | VI | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sex | M | F | M | F | M | F | M | F | M | F | M | F |
| Colour | 3.4 | 3.5 | 3.0 | 2.8 | 3.2 | 3.2 | 3.3 | 3.3 | 3.8 | 3.8 | 3.6 | 3.7 |
| Defects | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| Fleshing | 3.4 | 3.5 | 3.2 | 3.0 | 3.2 | 3.4 | 3.4 | 3.5 | 3.6 | 3.8 | 3.5 | 3.7 |
| Uniformity | 3.8 | 3.8 | 3.5 | 3.4 | 3.0 | 3.5 | 3.4 | 3.4 | 3.4 | 3.5 | 3.3 | 3.3 |
| Total | 3.2 | 3.2 | 3.0 | 2.8 | 2.9 | 3.1 | 3.1 | 3.1 | 3.2 | 3.3 | 3.2 | 3.2 |
| Total high quality* | 3.5 | 3.6 | 3.2 | 3.1 | 3.1 | 3.4 | 3.4 | 3.4 | 3.6 | 3.7 | 3.5 | 3.6 |
| Grade | A | | B | | B | | B | | A | | A | |
| Classification | 3 | | 6 | | 5 | | 4 | | 1 | | 2 | |

* Translation of the Dutch term (Alg. Uitgezonderd beschadiging).

TABLE (17).

Average food consumption (gr) food/day of Experiment I.

| Group No. | Rep lica | Sex | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | week 7 |
|---|---|---|---|---|---|---|---|---|---|
| I | 4 | M | 11.24 | 23.69 | 37.79 | 53.09 | 67.56 | 74.06 | 86.91 |
| | 4 | F | 10.11 | 21.45 | 33.93 | 49.13 | 66.95 | 66.89 | 79.47 |
| II | 4 | M | 9.63 | 21.58 | 34.22 | 50.84 | 64.88 | 72.90 | 89.63 |
| | 4 | F | 9.90 | 21.70 | 35.27 | 49.54 | 62.66 | 69.14 | 83.64 |
| III | 4 | M | 9.95 | 23.03 | 37.16 | 53.65 | 67.55 | 74.78 | 90.97 |
| | 4 | F | 10.06 | 23.27 | 36.96 | 52.05 | 66.22 | 71.16 | 87.04 |
| IV | 4 | M | 10.53 | 21.24 | 36.33 | 50.53 | 66.69 | 74.19 | 91.78 |
| | 4 | F | 9.58 | 21.79 | 34.17 | 51.93 | 64.68 | 68.53 | 85.12 |
| V | 4 | M | 10.21 | 21.44 | 35.15 | 50.39 | 65.43 | 42.45 | 87.65 |
| | 4 | F | 11.08 | 20.95 | 35.66 | 45.82 | 60.44 | 65.22 | 77.54 |
| VI | 4 | M | 10.17 | 21.27 | 34.09 | 49.48 | 62.18 | 72.15 | 85.76 |
| | 4 | F | 9.91 | 19.99 | 31.15 | 44.46 | 58.38 | 63.29 | 78.56 |

TABLE (18).

Chicks mortality Record of Experiment I.

| Sex | Control Group I | Group II | Group III | Group IV | Group V | Group VI |
|---|---|---|---|---|---|---|
| M | 1 | 3 | 3 | – | 2 | 1 |
| F | 3 | 1 | 4 | 2 | 4 | – |
| Total | 4 | 4 | 7 | 2 | 6 | 1 |

TABLE 19. Average cumulative feed efficiency of Experiment I.

| Group No. | Re-plica | Sex | week 1 | weeks 2 | weeks 3 | weeks 4 | weeks 5 | weeks 6 | weeks 7 |
|---|---|---|---|---|---|---|---|---|---|
| I | 4 | M | 1.345 | 1.502 | 1.620 | 1.717 | 1.837 | 1.942 | 2.062 |
| | 4 | F | 1.287 | 1.530 | 1.655 | 1.767 | 1.887 | 2.030 | 2.160 |
| II | 4 | M | 1.585 | 1.732 | 1.777 | 1.875 | 1.997 | 2.125 | 2.237 |
| | 4 | F | 1.527 | 1.655 | 1.810 | 1.920 | 2.042 | 2.157 | 2.272 |
| III | 4 | M | 1.455 | 1.625 | 1.762 | 1.882 | 2.022 | 2.127 | 2.252 |
| | 4 | F | 1.487 | 1.647 | 1.807 | 1.940 | 2.060 | 2.185 | 2.317 |
| IV | 4 | M | 1.415 | 1.535 | 1.712 | 1.797 | 1.940 | 2.067 | 2.195 |
| | 4 | F | 1.447 | 1.687 | 1.780 | 1.935 | 2.070 | 2.190 | 2.320 |
| V | 4 | M | 1.465 | 1.595 | 1.700 | 1.797 | 1.920 | 2.000 | 2.105 |
| | 4 | F | 1.705 | 1.680 | 1.822 | 1.862 | 1.970 | 2.057 | 2.165 |
| VI | 4 | M | 1.372 | 1.540 | 1.667 | 1.777 | 1.900 | 1.995 | 2.100 |
| | 4 | F | 1.352 | 1.540 | 1.665 | 1.760 | 1.892 | 2.010 | 2.137 |

TABLE 20. Average Weight (gr) of the Males and Females of Experiment I.

| Group No. | Re-plica. | Sex. | week 1 | weeks 2 | weeks 3 | weeks 4 | weeks 5 | weeks 6 | weeks 7 |
|---|---|---|---|---|---|---|---|---|---|
| I | 4 | M | 101.25 | 207.25 | 357.50 | 554.50 | 778.75 | 1004.75 | 1243.00 |
| | 4 | F | 98.25 | 187.75 | 323.00 | 498.75 | 695.75 | 888.50 | 1095.00 |
| II | 4 | M | 87.00 | 171.25 | 302.50 | 478.75 | 678.75 | 880.50 | 1119.00 |
| | 4 | F | 89.00 | 177.75 | 302.75 | 468.25 | 657.25 | 848.25 | 1063.75 |
| III | 4 | M | 92.25 | 187.75 | 323.50 | 505.25 | 706.00 | 919.25 | 1153.00 |
| | 4 | F | 92.75 | 186.75 | 317.00 | 486.00 | 684.50 | 874.25 | 1090.00 |
| IV | 4 | M | 94.75 | 187.50 | 321.00 | 504.25 | 709.75 | 920.00 | 1160.75 |
| | 4 | F | 89.75 | 173.00 | 301.00 | 470.75 | 662.00 | 847.00 | 1057.50 |
| V | 4 | M | 94.00 | 183.75 | 319.50 | 501.00 | 709.25 | 936.00 | 1182.25 |
| | 4 | F | 90.00 | 179.50 | 305.50 | 472.00 | 662.50 | 857.50 | 1068.50 |
| VI | 4 | M | 95.00 | 187.25 | 318.50 | 495.75 | 696.25 | 918.00 | 1160.50 |
| | 4 | F | 94.00 | 178.25 | 300.25 | 463.25 | 649.00 | 834.00 | 1043.75 |

TABLE 21.

Body weight and feed conversion of Experiment I.

| Group No. | | Av. 7the week body Wt. for both sexes (gr) | 7th week Av. feed conv. for both sexes (gr) |
|---|---|---|---|
| 1 | Animal protein + all N.R.C. req. | 1169.0 | 2.111 |
| 2 | plant protein + total lysine * .95% / ** .95% + 4% vegetable oil. + T. Methionine * 1.07% / ** 1.00% | 1091.37 | 2.254 |
| 3 | plant p. + T. lysine [1.18% / 1.18%] + 4% veg. oil. + T. Methionine [1.07% / 1.00%] | 1121.50 | 2.284 |
| 4 | plant p. + T. lysine [1.41% / 1.41%] + 4% veg. oil. + T. Methionine [1.17% / 1.15%] | 1109.12 | 2.257 |
| 5 | plant p. + T. lysine [1.36% / 1.36%] + 8% veg. oil. + T. Methionine [1.12% / 1.11%] | 1125.37 | 2.135 |
| 6 | plant p. + T. lysine [1.80% / 1.80%] + 8% veg. oil. + T. Methionine [1.17% / 1.17%] | 1102.12 | 2.118 |

* From 0 - 4 weeks
** From 4 - 7 weeks

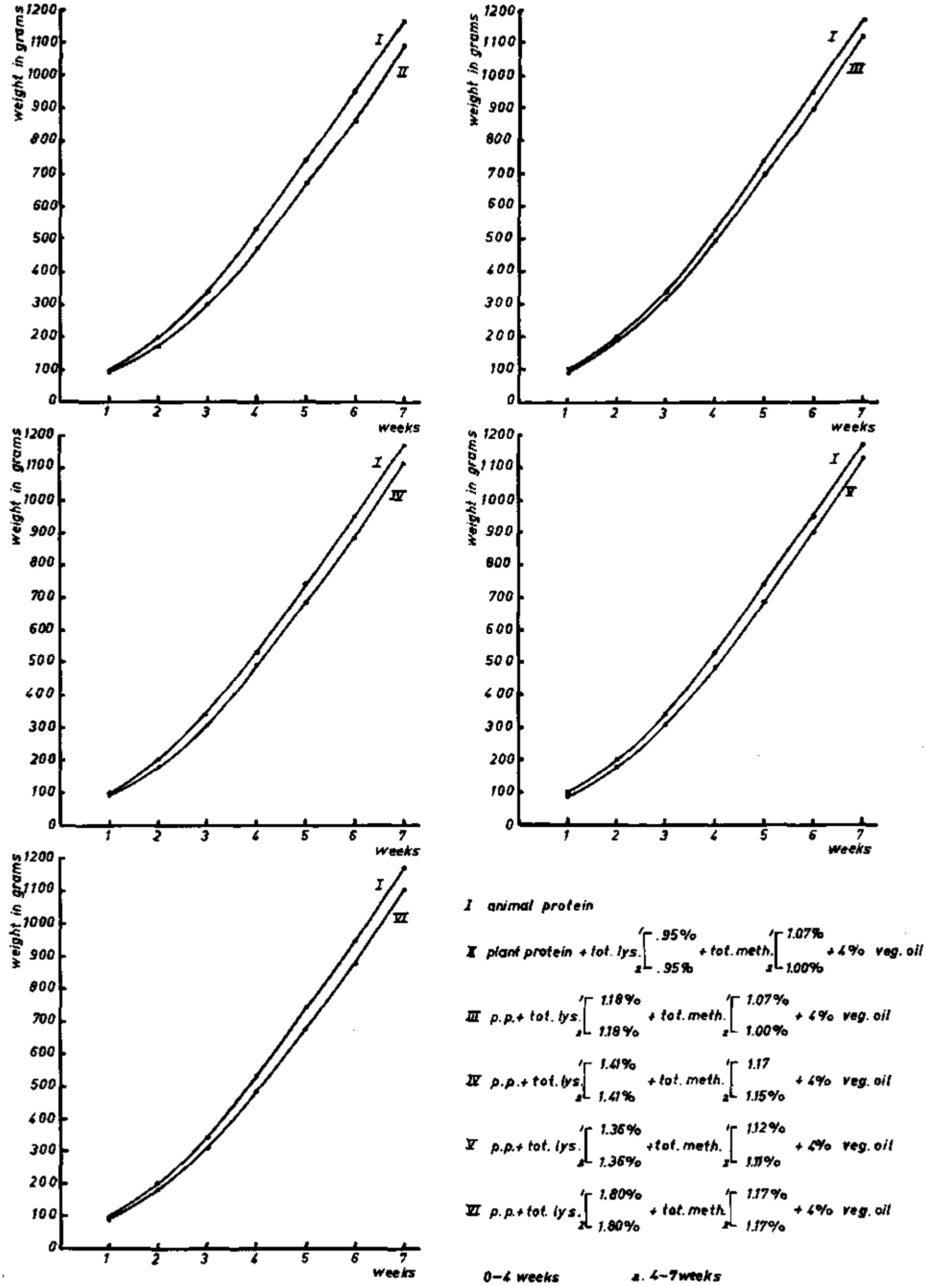


Fig. 3. Comparison between animal protein diet and plant protein diets supplemented with different levels of lysine, methionine and vegetable oil, and the effect of these supplements on chicks' weight at 7 weeks. Exp. I.

TABLE 22.

Average weight (gr) of Males and Females chicks in Experiment I.

| | Sex | Gr. 1 | Gr. 2 | Gr. 3 | Gr. 4 | Gr. 5 | Gr. 6 |
|---|---|---|---|---|---|---|---|
| 7th week | M | 1243.0 | ** 1119.0 | ** 1153.0 | ** 1160.8 | ** 1182.3 | ** 1160.5 |
| weight (gr) | F | 1095.0 | * 1063.8 | 1090.0 | * 1057.5 | 1068.5 | ** 1043.8 |

* $P < .05$
** $P < .01$

TABLE 23.

Average cumulative feed efficiency for both sexes of Experiment I.

| | Sex | Gr. 1 | Gr. 2 | Gr. 3 | Gr. 4 | Gr. 5 | Gr. 6 |
|---|---|---|---|---|---|---|---|
| 7th week Cm | M | 2.06 | ** 2.23 | ** 2.25 | ** 2.19 | 2.10 | 2.10 |
| Feed eff. | F | 2.16 | ** 2.27 | ** 2.31 | ** 2.32 | 2.16 | 2.13 |

* $P < .05$
** $P < .01$

Experiment II.

The stock and management in this experiment were similar to the previous one.

Experiment diets.

Experiment II was conducted in order to obtain further information concerning amino acid supplementation especially lysine and methionine by applying different levels of lysine preparation in diets 2, 3, 4, 5, 6 ranging from .50 - 1.00 percent only, and .11 - .19 percent methionine. (Lysine quantities are less than those used in the first experiment). The vegetable oil (sesame oil) quantity is 4 percent only in all rations except the control; other ingredients such as sesame meal, barley, millet, vitamins and minerals are the same as in the first experiment. Samples from all rations have been analysed and compositions of the diets have been calculated. Details of the experimental rations are given in the following tables.

TABLE 24.

Diets and plan Experiment II.

| Ingredient | Con-* trol | 0-4 weeks | | | | | ** Control | 4-7 weeks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 |
| Barley | -- | 18 | 18 | 18 | 18 | 18 | -- | 22 | 22 | 22 | 22 | 22 |
| Millet | -- | 10 | 10 | 10 | 10 | 10 | -- | 10 | 10 | 10 | 10 | 10 |
| Y. Corn | 43 | 30 | 30 | 30 | 30 | 30 | 48.5 | 30 | 30 | 30 | 30 | 30 |
| Sesame Meal | -- | 34 | 34 | 34 | 34 | 34 | -- | 30 | 30 | 30 | 30 | 30 |
| Alfalfa Meal | 2 | 5 | 5 | 5 | 5 | 5 | 2 | 5 | 5 | 5 | 5 | 5 |
| Vit. A/D3 prep. | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 |
| Vital | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Minerals | 2 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 2 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| CaHPO4 | -- | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | -- | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| Hydan | 0.1 | -- | -- | 0.11 | 0.11 | 0.19 | 0.1 | -- | -- | 0.11 | 0.11 | 0.19 |
| Lysine prep. | -- | 0.50 | 0.60 | 0.73 | 0.87 | 1.00 | -- | 0.50 | 0.60 | 0.73 | 0.87 | 1.00 |
| Sesame oil | -- | 4 | 4 | 4 | 4 | 4 | -- | 4 | 4 | 4 | 4 | 4 |
| Vit. B12 | -- | + | + | + | + | + | -- | + | + | + | + | + |
| Milo | 5 | -- | -- | -- | -- | -- | 5 | -- | -- | -- | -- | -- |
| Oats | 5 | -- | -- | -- | -- | -- | 5 | -- | -- | -- | -- | -- |
| Wheat | 5 | -- | -- | -- | -- | -- | 5 | -- | -- | -- | -- | -- |
| Animal fat | 3 | -- | -- | -- | -- | -- | 3 | -- | -- | -- | -- | -- |
| Soybean Meal | 9.5 | -- | -- | -- | -- | -- | 9 | -- | -- | -- | -- | -- |
| Sesame cake Meal | 3 | -- | -- | -- | -- | -- | 3 | -- | -- | -- | -- | -- |
| Sunflower Meal | 3 | -- | -- | -- | -- | -- | 3 | -- | -- | -- | -- | -- |
| Cottonseed Meal | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Fish Meal | 11 | -- | -- | -- | -- | -- | 8 | -- | -- | -- | -- | -- |
| Meat Meal | 2 | -- | -- | -- | -- | -- | 2 | -- | -- | -- | -- | -- |
| Wheypowder | 3 | -- | -- | -- | -- | -- | 3 | -- | -- | -- | -- | -- |
| | 100.22 | 105.52 | 105.62 | 105.86 | 106.00 | 106.21 | 100.22 | 105.52 | 105.62 | 105.86 | 106.00 | 106.21 |

* protein ± 24 - Cal/kg ± 3200
** protein ± 20.5 - Cal/kg ± 3200

TABLE 25.

Calculated Compositions of Experiment II.

| Nutrient | 0-4 weeks groups | | | | | 4-7 weeks groups | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 2 | 3 | 4 | 5 | 6 |
| Crude protein [2] | ± 23 | ± 23 | ± 23 | ± 23 | ± 23 | ± 22 | ± 22 | ± 22 | ± 22 | ± 22 |
| Metabolizable E. Cal/kg. | ± 2700 | ± 2700 | ± 2700 | ± 2700 | ± 2700 | ± 2700 | ± 2700 | ± 2700 | ± 2700 | ± 2700 |
| Fat | 6.14 | 6.13 | 6.12 | 6.11 | 6.10 | 6.21 | 6.20 | 6.19 | 6.18 | 6.17 |
| Fiber | 6.65 | 6.65 | 6.63 | 6.62 | 6.61 | 6.65 | 6.65 | 6.63 | 6.62 | 6.61 |
| Amino Acids (%) [1] | | | | | | | | | | |
| Lysine | .97 | 1.05 | 1.14 | 1.23 | 1.33 | .95 | 1.02 | 1.11 | 1.21 | 1.30 |
| Methionine + Cystine | 1.07 | 1.07 | 1.17 | 1.17 | 1.24 | 1.00 | 1.00 | 1.10 | 1.10 | 1.18 |
| Arginine | 2.20 | 2.20 | 2.19 | 2.19 | 2.18 | 2.01 | 2.01 | 2.00 | 2.00 | 2.00 |
| Tryptophan | .26 | .26 | .26 | .26 | .26 | .26 | .25 | .25 | .25 | .25 |
| Glycine | 1.03 | 1.02 | 1.02 | 1.02 | .96 | .95 | .95 | .95 | .95 | .95 |
| Isoleucine | .80 | .79 | .79 | .79 | .79 | .75 | .75 | .75 | .74 | .74 |
| Leucine | 1.67 | 1.67 | 1.66 | 1.66 | 1.66 | 1.58 | 1.58 | 1.58 | 1.57 | 1.57 |
| Phenylalanine + Tyrosine | 1.82 | 1.82 | 1.81 | 1.81 | 1.81 | 1.71 | 1.71 | 1.71 | 1.71 | 1.70 |
| Threonine | .77 | .77 | .76 | .76 | .76 | .72 | .72 | .72 | .72 | .71 |
| Valine | .98 | .97 | .97 | .97 | .97 | .93 | .93 | .93 | .93 | .92 |
| Histidine | .51 | .51 | .51 | .51 | .51 | .48 | .48 | .48 | .48 | .48 |
| Minerals (%) | | | | | | | | | | |
| Calcium % | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| Phosphorus % | .81 | .81 | .81 | .81 | .80 | .77 | .77 | .76 | .76 | .76 |
| Sodium % | .20 | .20 | .20 | .20 | .20 | .19 | .19 | .19 | .19 | .19 |
| K % | .75 | .75 | .74 | .74 | .74 | .65 | .65 | .65 | .65 | .65 |
| Zinc. PPM | 40.05 | 40.01 | 39.92 | 39.87 | 39.79 | 47.26 | 47.22 | 47.11 | 47.05 | 46.95 |

(1) Please see Chap. II. (Amino acids assay).
(2) From 4 - 7 weeks the protein level was reduced.

TABLE 26.

Calculated Compositions of the rations of Experiment II.

| Nutrient | 0 - 4 weeks | | | | | 4 - 7 weeks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 2 | 3 | 4 | 5 | 6 |
| Vitamins | | | | | | | | | | |
| Vit. A U.S.P.U. P/kg | 13130 | 13117 | 13088 | 13070 | 13044 | 13129 | 13116 | 13086 | 13069 | 13043 |
| Riboflavin Mg/kg | 5.40 | 5.40 | 5.40 | 5.40 | 5.39 | 5.36 | 5.36 | 5.35 | 5.34 | 5.33 |
| Pantothenic acid Mg/kg | 11.77 | 11.76 | 11.73 | 11.72 | 11.69 | 11.85 | 11.83 | 11.81 | 11.79 | 11.77 |
| Choline Mg/kg | 1137 | 1136 | 1133 | 1132 | 1130 | 1123 | 1122 | 1119 | 1118 | 1105 |
| Niacin Mg/kg | 35.88 | 35.84 | 35.76 | 35.72 | 35.65 | 37.45 | 37.42 | 37.33 | 37.28 | 37.21 |
| Thiamine Mg/kg | 3.72 | 3.72 | 3.71 | 3.71 | 3.70 | 3.78 | 3.78 | 3.77 | 3.76 | 3.76 |
| Vit. $B_{12}$ | + | + | + | + | + | + | + | + | + | + |

## TABLE 27.

Lysine and Methionine content, added to the rations of Experiment II.

| | 0-4 weeks groups | | | | | 4-7 weeks groups | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 2 | 3 | 4 | 5 | 6 |
| Lysine content * of the ration | .66 | .66 | .66 | .66 | .66 | .63 | .63 | .63 | .63 | .63 |
| Lysine prep. added | .50 | .60 | .73 | .87 | 1.00 | .50 | .60 | .73 | .87 | 1.00 |
| Active lysine** added | .37 | .45 | .55 | .65 | .75 | .37 | .45 | .55 | .65 | .75 |
| Total lysine | .97 | 1.05 | 1.14 | 1.23 | 1.33 | .95 | 1.02 | 1.11 | 1.21 | 1.30 |
| Methionine + cystine content of the ration | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 |
| Methionine added | - | - | .11 | .11 | .19 | - | - | .11 | .11 | .19 |
| Total methionine | 1.07 | 1.07 | 1.17 | 1.17 | 1.24 | 1.00 | 1.00 | 1.10 | 1.10 | 1.18 |

* For feed analysis and amino acid content, please see data of experiment I.
** Lysine preparation, 75% active.

Result and discussion of Experiment II.

On the basis of the favorable results in experiment I, the study was expanded in experiment II. High lysine level and vegetable oil proved to be of no economical benefit, so it has been reduced, as is shown in table (24). New lysine levels were established ranging between .97 and 1.33 of the diets, but the methionine was left almost as it is in experiment I. The basal diet used for this experiment was also the same.

The result of 7 weeks average weights, feed efficiency (feed/gain per day) and food consumption (food/day) for the second experiment are presented in tables (29, 31, 32).

The results of this experiment indicate that additive lysine to ration 3 did not improve the average weight, while it did slightly decrease the feed efficiency, and in ration 4, when lysine and methionine levels increased slightly, the weight decreased while feed efficiency was extremely high, as it is in table (33). This picture was not so clear in ration 6 of this experiment. In ration 5 when lysine was increased to 1.23% (the methionine percent was left as it is in ration 4), the weight moved up slightly, but the feed efficiency was less. This agrees with the results of experiment I, that increasing the levels of lysine and methionine in the diet depressed growth, thus coinciding once more with the findings of Snetsinger and Scott (1961).

In general the females response to additive lysine was higher than that of males and this also agrees with the result of the first experiment, so we can clearly recognize that there is less difference in the final weights if the response of the females is compared to the control. The metabolizable energy (± 2700) Cal/kg, and the crude protein level ± 23*, ± 22**, was not changed, in this experiment.

The difference in weight between chicks fed on an animal protein diet and those fed on a plant protein diet in general is not high but statistical significance is still there, and this can be recognized in tables (34, 35).

The mortality rate was very low,as is shown in table (30).

At the end of the feeding trial of experiment II, all the birds were sent to the slaughter house (Pluimveeslachterij "WEZEP" N.V.) to be scored and graded according to their commercial carcass quality. The result is given in table (28). From the presented result we can see clearly that all rations have been graded equally.

---

* First 4 weeks
** 4-7 weeks

TABLE 28.

Broiler Carcass Quality of all groups in Experiment II.

| | |
|---|---|
| Colour | 3.0 |
| Defects* | --- |
| Fleshing | 3.2 |
| Uniformity | 3.5 |
| Total | 3.2 |
| Total high quality | 3.5 |
| Grade | A, B, C |

* No value given since all the birds have brest blisters.

TABLE 29.

Average food consumption (gr) food/day of Experiment II.

| Group No. | Rep-lica | Sex | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | week 7 |
|---|---|---|---|---|---|---|---|---|---|
| I | 4 | M | 11.24 | 25.44 | 40.08 | 53.21 | 71.51 | 78.48 | 87.85 |
| | 4 | F | 11.20 | 24.36 | 35.35 | 47.76 | 62.36 | 69.19 | 73.84 |
| II | 4 | M | 9.99 | 22.05 | 37.40 | 49.28 | 68.47 | 76.95 | 88.56 |
| | 4 | F | 10.98 | 23.25 | 35.89 | 47.35 | 63.84 | 72.24 | 77.81 |
| III | 4 | M | 10.62 | 22.71 | 36.64 | 51.38 | 70.06 | 80.23 | 88.84 |
| | 4 | F | 11.83 | 22.45 | 36.08 | 47.23 | 63.42 | 70.66 | 78.81 |
| IV | 4 | M | 11.66 | 23.14 | 36.64 | 50.81 | 69.02 | 78.15 | 86.30 |
| | 4 | F | 11.42 | 23.57 | 36.15 | 46.96 | 63.65 | 71.24 | 68.03 |
| V | 4 | M | 10.48 | 22.43 | 38.70 | 50.17 | 69.31 | 79.29 | 88.95 |
| | 4 | F | 10138 | 22.79 | 36.70 | 46.99 | 63.63 | 73.32 | 76.51 |
| VI | 4 | M | 10.26 | 22.87 | 37.56 | 50.05 | 69.93 | 78.85 | 88.13 |
| | 4 | F | 10.74 | 22.77 | 36.79 | 45.65 | 62.70 | 68.40 | 74.01 |

TABLE 30.

Chick Mortality record of Experiment II.

| Sex | Control Group I | Group II | Group III | Group IV | Group V | Group VI |
|---|---|---|---|---|---|---|
| M | 1 | - | 2 | 1 | 2 | 3 |
| F | 4 | 3 | 2 | - | 2 | 1 |
| Total | 5 | 3 | 4 | 1 | 4 | 4 |

TABLE 31.

Average weight (gr) of the Males and Females of Experiment II.

| Group No. | Rep-lica | Sex | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | week 7 |
|---|---|---|---|---|---|---|---|---|---|
| I | 4 | M | 107.50 | 220.75 | 381.75 | 573.00 | 795.75 | 1031.25 | 1269.00 |
| | 4 | F | 103.25 | 209.00 | 325.00 | 517.75 | 704.25 | 916.50 | 1075.50 |
| II | 4 | M | 89.25 | 177.75 | 312.00 | 484.50 | 699.75 | 944.00 | 1132.75 |
| | 4 | F | 94.50 | 186.50 | 314.25 | 471.50 | 658.25 | 872.50 | 1021.25 |
| III | 4 | M | 93.75 | 181.50 | 319.25 | 491.00 | 705.75 | 943.00 | 1147.50 |
| | 4 | F | 93.75 | 184.50 | 311.75 | 461.25 | 637.75 | 841.25 | 1006.50 |
| IV | 4 | M | 97.75 | 189.25 | 328.75 | 495.00 | 707.00 | 947.75 | 1127.75 |
| | 4 | F | 96.50 | 187.00 | 313.75 | 461.75 | 646.75 | 851.25 | 1011.50 |
| V | 4 | M | 96.00 | 185.00 | 321.75 | 490.75 | 704.00 | 942.50 | 1137.00 |
| | 4 | F | 96.50 | 190.25 | 319.00 | 472.25 | 655.50 | 866.00 | 1015.00 |
| VI | 4 | M | 96.50 | 191.25 | 329.75 | 498.75 | 713.00 | 943.25 | 1159.50 |
| | 4 | F | 97.00 | 189.00 | 317.00 | 466.00 | 647.50 | 849.00 | 1001.50 |

TABLE 32.

Average cumulative Feed efficiency of Experiment II.

| Group No. | Rep-lica | Sex | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | week 7 |
|---|---|---|---|---|---|---|---|---|---|
| I | 4 | M | 1.325 | 1.485 | 1.607 | 1.730 | 1.882 | 1.990 | 2.102 |
| | 4 | F | 1.445 | 1.567 | 1.642 | 1.772 | 1.932 | 2.060 | 2.245 |
| II | 4 | M | 1.702 | 1.722 | 1.840 | 1.902 | 2.005 | 1.062 | 2.272 |
| | 4 | F | 1.687 | 1.737 | 1.847 | 1.942 | 2.080 | 2.175 | 2.402 |
| III | 4 | M | 1.710 | 1.772 | 1.817 | 1.920 | 2.042 | 2.125 | 2.295 |
| | 4 | F | 1.857 | 1.782 | 1.880 | 2.000 | 2.150 | 2.222 | 2.415 |
| IV | 4 | M | 1.705 | 1.742 | 1.852 | 1.957 | 2.060 | 2.115 | 2.325 |
| | 4 | F | 1.637 | 1.755 | 1.865 | 1.992 | 2.120 | 2.202 | 2.332 |
| V | 4 | M | 1.562 | 1.687 | 1.847 | 1.932 | 2.042 | 2.115 | 2.312 |
| | 4 | F | 1.527 | 1.637 | 1.807 | 1.927 | 2.080 | 2.192 | 2.407 |
| VI | 4 | M | 1.505 | 1.642 | 1.780 | 1.887 | 2.032 | 2.125 | 2.265 |
| | 4 | F | 1.530 | 1.657 | 1.832 | 1.937 | 2.082 | 2.155 | 2.352 |

TABLE (33).

Body weights and feed conversion of Experiment II.

| Group No. | Treatment | Av. 7th week body wt. for both sexes (gr) | 7te week Av. feed conv. for both sexes (gr) |
|---|---|---|---|
| 1 | Animal protein + All N.R.C. req. | 1185.75 | 2.174 |
| 2 | plant protein + Total lysine [.97%* / .95%**] + Total methionine [1.07% / 1.00%] + 4% vegetable oil. | 1077.00 | 2.337 |
| 3 | plant protein + Total lysine [1.05% / 1.02%] + Total methionine [1.07% / 1.00%] + 4% vegetable oil. | 1077.00 | 2.355 |
| 4 | plant protein + Total lysine [1.14% / 1.11%] + Total methionine [1.17% / 1.10%] + 4% vegetable oil. | 1069.62 | 2.329 |
| 5 | plant protein + Total lysine [1.23% / 1.21%] + Total methionine [1.17% / 1.10%] + 4% vegetable oil | 1076.00 | 2.360 |
| 6 | plant protein + Total lysine [1.33% / 1.30%] + Total methionine [1.24% / 1.18%] + 4% vegetable oil | 1080.50 | 2.309 |

* From 0-4 weeks
** From 4-7 weeks

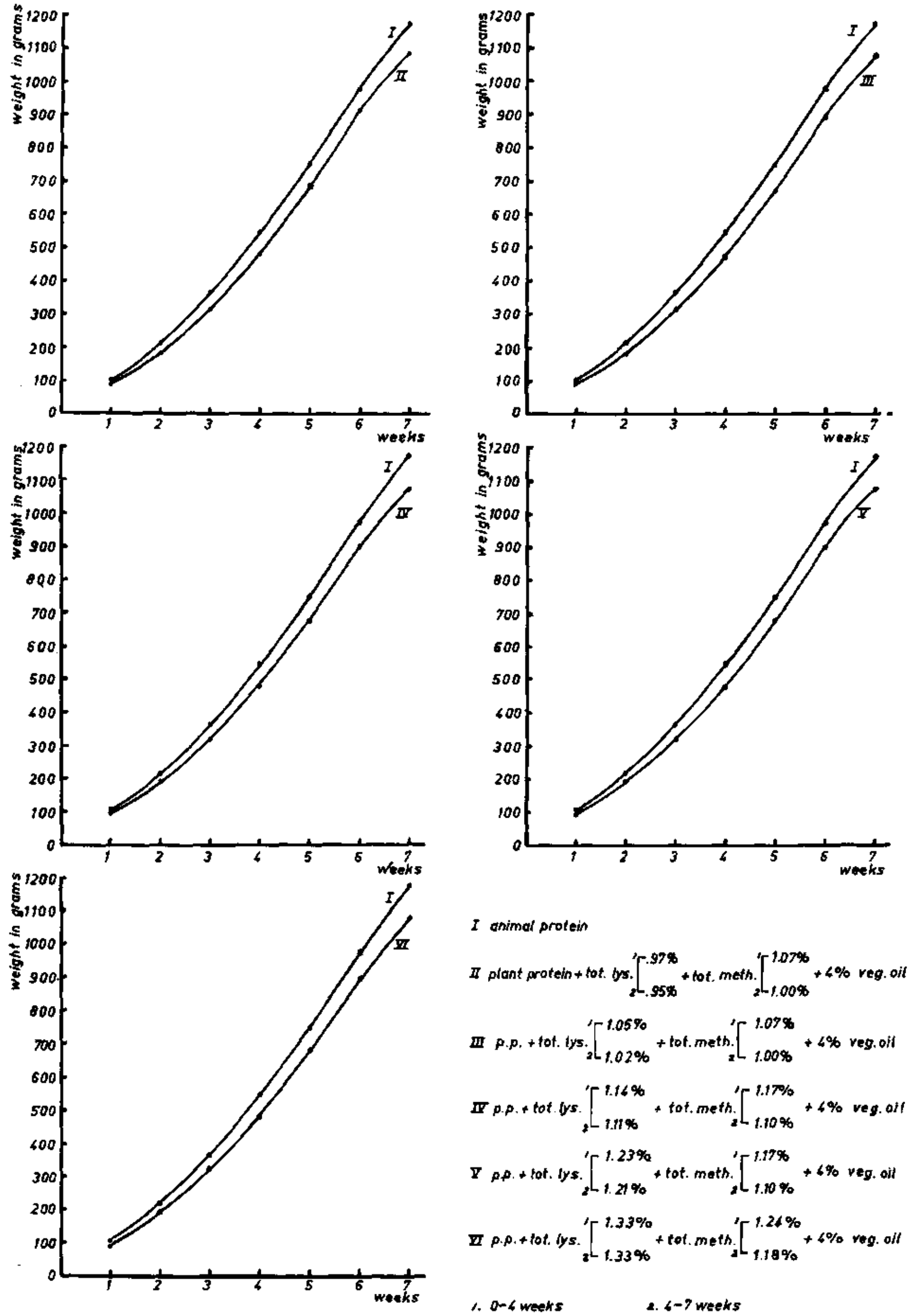


Fig. 4. Comparison between animal protein diet and plant protein diets supplement with different levels of lysine and methionine, and the effect of these supplement on chicks' weight at 7 weeks. Exp. II.

TABLE (34).

Average weight of chicks in Experiment II.

| | Sex | Gr. 1 | Gr. 2 | Gr. 3 | Gr. 4 | Gr. 5 | Gr. 6 |
|---|---|---|---|---|---|---|---|
| 7th week weight | M | 1269.00 | ** 1132.75 | ** 1147.50 | ** 1127.75 | ** 1137.00 | ** 1159.50 |
| (gr) | F | 1075.50 | ** 1021.25 | ** 1006.50 | ** 1011.50 | ** 1015.00 | ** 1001.50 |

* $P < .05$
** $P < .01$

TABLE (35).

Average cumulative feed efficiency of Experiment II.

| | Sex | Gr. 1 | Gr. 2 | Gr. 3 | Gr. 4 | Gr. 5 | Gr. 6 |
|---|---|---|---|---|---|---|---|
| 7th week Cu. F. | M | 2.102 | ** 2.272 | ** 2.295 | ** 2.325 | ** 2.312 | ** 2.265 |
| efficiency | F | 2.245 | 2.402 | ** 2.415 | 2.332 | ** 2.407 | * 2.352 |

* $P < .05$
** $P < .01$

## Experiment III.

The stock and management in this experiment were similar to the previous ones except that the chicks were placed differently as is shown in Table (36).

TABLE 36.

Random Selection Table

| Group | Male Lot No. | | | | | Female Lot No. | | | |
|---|---|---|---|---|---|---|---|---|---|
| I | 1 | 24 | 27 | 43 | " | 12 | 37 | 38 | 40 |
| II | 14 | 20 | 32 | 39 | " | 13 | 16 | 35 | 41 |
| III | 6 | 22 | 42 | 45 | " | 17 | 19 | 25 | 34 |
| IV | 5 | 30 | 44 | 47 | " | 3 | 8 | 9 | 23 |
| V | 21 | 28 | 36 | 48 | " | 2 | 7 | 26 | 29 |
| VI | 4 | 11 | 15 | 18 | " | 10 | 31 | 33 | 46 |

Experimental Diets.

Experiment III was made in order to verify the evidence obtained in the previous experiments, using the second ration as a basal diet consisting of 0.50% lysine and no methionine.

However, the basal series was changed somewhat in rations (5,6) by replacing barley and millet by yellow corn to investigate the fiber effect.

Sesame meal, alfalfa meal and minerals were the same as in the first and second experiments.

Extra choline was added in rations 3, 4, 5, 6 to check its effect and the vitamin A content was increased in ration 4 only, for similar reason. Samples from all diets have been analysed and the composition of the rations has been calculated. Details of the experimental diets are given in the following tables.

TABLE 37

Diets and Plan Experiment III.

| Ingredient | Con-. trol | 0 - 4 weeks | | | | | Control | 4 - 7 weeks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 |
| Barley | --- | 18 | 18 | 18 | --- | --- | --- | 22 | 22 | 22 | --- | --- |
| Millet | --- | 10 | 10 | 10 | --- | --- | --- | 10 | 10 | 10 | --- | --- |
| Y. Corn | 43 | 30 | 30 | 30 | 58 | 58 | 48.5 | 30 | 30 | 30 | 62 | 62 |
| Sesame Meal | --- | 34 | 34 | 34 | 34 | 34 | --- | 30 | 30 | 30 | 30 | 30 |
| Alfalfa Meal | 2 | 5 | 5 | 5 | 5 | 5 | 2 | 5 | 5 | 5 | 5 | 5 |
| Vit. A/D3 prep. | 0.12 | 0.12 | 0.12 | 0.13 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 |
| Vital | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Minerals | 2 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 2 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| CaHP04 | --- | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | --- | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| Hydan | 0.1 | --- | --- | --- | --- | --- | 0.1 | --- | --- | --- | --- | --- |
| Lysine prep. | --- | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | --- | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| Sesame Oil | --- | 4 | 4 | 4 | 4 | 4 | --- | 4 | 4 | 4 | 4 | 4 |
| Vit. B12 | --- | + | + | + | + | + | --- | + | + | + | + | + |
| Milo | 5 | --- | --- | --- | --- | --- | 5 | --- | --- | --- | --- | --- |
| Oats | 5 | --- | --- | --- | --- | --- | 5 | --- | --- | --- | --- | --- |
| Wheat | 5 | --- | --- | --- | --- | --- | 5 | --- | --- | --- | --- | --- |
| Animal fat | 3 | --- | --- | --- | --- | --- | 3 | --- | --- | --- | --- | --- |
| Soybean Meal | 9.5 | --- | --- | --- | --- | --- | 9 | --- | --- | --- | --- | --- |
| Sesame cake Meal | 3 | --- | --- | --- | --- | --- | 3 | --- | --- | --- | --- | --- |
| Sunflower Meal | 3 | --- | --- | --- | --- | --- | 3 | --- | --- | --- | --- | --- |
| Cottonseed Meal | 2 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Fish Meal | 11 | --- | --- | --- | --- | --- | 8 | --- | --- | --- | --- | --- |
| Meat Meal | 2 | --- | --- | --- | --- | --- | 2 | --- | --- | --- | --- | --- |
| Wheypowder | 3 | --- | --- | --- | --- | --- | 3 | --- | --- | --- | --- | --- |
| | 100.22 | 105.52 | 105.52 | 105.53 | 105.52 | 105.52 | 100.22 | 105.52 | 105.52 | 105.52 | 105.52 | 105.52 |

TABLE (38).

Calculated Compositions of Diet 5, Experiment III.

| Nutrient | 0 - 4 weeks | 4 - 7 weeks |
|---|---|---|
| Crude protein % | ± 23 | ± 21.5 |
| Dig. Protein % | ± 19 | ± 17.5 |
| M.E. Cal/kg | ± 2800 | ± 2800 |
| Fat | 6.34 | 6.52 |
| Fiber | 5.6 | 5.4 |
| Amino Acids % | | |
| Lysine | .97 | .94 |
| Methionine + Cystine | 1.08 | 1.02 |
| Arginine | 2.19 | 1.99 |
| Tryptophan | .25 | .23 |
| Glycine | 1.02 | .96 |
| Isoleucine | .79 | .74 |
| Leucine | 1.79 | 1.71 |
| Phenylalanine + Tyrosine | 1.82 | 1.70 |
| Threonine | .78 | .73 |
| Valine | 1.01 | .96 |
| Histidine | .54 | .51 |
| Minerals % | | |
| Calcium | 1.20 | 1.12 |
| Phosphorus | .78 | .74 |
| Sodium | .19 | .18 |
| Potassium | .74 | .64 |
| Zinc P.P.M | 18.27 | 18.35 |
| Vitamins | | |
| Vit.A U.S.P.U. p/kg | 14268 | 14436 |
| Riboflavin Mg/kg | 5.13 | 5.05 |
| Pantothenic Acid Mg/kg | 11.12 | 11.12 |
| Choline Mg/kg | 952 | 912 |
| Niacin Mg/kg | 30.39 | 30.81 |
| Thiamine Mg/kg | 3.40 | 3.45 |
| Vit. B.12 | + | + |

TABLE (39).

Choline and Vitamin A content and the addition to the third Experiment rations.

| | 0 - 4 weeks | | | | | Con-trol | 4 - 7 weeks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 |
| Vit. A content of the ration | 13088 | 13088 | 13088 | 14268 | 14268 | | 13129 | 13129 | 13129 | 14436 | 14436 |
| Vit. A added | - | - | 2250 | - | - | | - | - | - | - | - |
| Total Vit. A | - | - | 15338 | - | - | | - | - | - | - | - |
| Choline content of the ration | 1137 | 1137 | 1137 | 952 | 952 | | 1123 | 1123 | 1123 | 912 | 912 |
| Choline added | - | 183 | 183 | 185 | 368 | | - | 197 | 197 | 211 | 408 |
| Total choline | 1137 | 1320 | 1320 | 1137 | 1320 | | 1123 | 1320 | 1320 | 1123 | 1320 |

TABLE 40.

Amino Acid Content of the Third Experiment (5, 6) Rations during the first (4) weeks.

| Amino Acids | Y.Corn 58% | Alfalfa M. 5% | Sesame M. 34% | Total Amino Acids % | |
|---|---|---|---|---|---|
| Lysine | 0.19 | 0.04 | 0.43 | 0.66 | |
| Methionine | 0.14 | 0.01 | 0.43 | 0.58 | |
| Methionine ) | 0.14 | 0.01 | 0.43 | 0.58 ) | 1.14 |
| Cystine ) | 0.18 | 0.01 | 0.37 | 0.56 ) | |
| Arginine | 0.30 | 0.04 | 1.97 | 2.31 | |
| Tryptophan | 0.05 | 0.01 | 0.20 | 0.26 | |
| Glycine | 0.25 | 0.04 | 0.79 | 1.08 | |
| Isoleucine | 0.22 | 0.03 | 0.58 | 0.83 | |
| Leucine | 0.80 | 0.06 | 1.03 | 1.89 | |
| Phenylalanine | 0.30 | 0.04 | 0.71 | 1.05 | |
| Phenylalanine) | 0.30 | 0.04 | 0.71 | 1.05 ) | 1.92 |
| Tyrosine ) | 0.26 | 0.03 | 0.58 | 0.87 ) | |
| Threonine | 0.23 | 0.03 | 0.56 | 0.82 | |
| Valine | 0.32 | 0.04 | 0.71 | 1.07 | |
| Histidine | 0.19 | 0.02 | 0.36 | 0.57 | |

TABLE 41.

Amino Acid Content fo the Third Experiment (5, 6) Rations (4-7) weeks.

| Amino Acids | Y.Corn 62% | Alfalfa M. 5% | Sesame M. 30% | Total Amino Acids % | |
|---|---|---|---|---|---|
| Lysine | 0.20 | 0.04 | 0.38 | 0.62 | |
| Methionine | 0.15 | 0.01 | 0.38 | 0.54 | |
| Methionine ) | 0.15 | 0.01 | 0.38 | 0.54 ) | 1.08 |
| Cystine ) | 0.20 | 0.01 | 0.33 | 0.54 ) | |
| Arginine | 0.32 | 0.04 | 1.74 | 2.10 | |
| Tryptophan | 0.05 | 0.01 | 0.18 | 0.24 | |
| Glycine | 0.27 | 0.04 | 0.70 | 1.01 | |
| Isoleucine | 0.24 | 0.03 | 0.51 | 0.78 | |
| Leucine | 0.85 | 0.06 | 0.90 | 1.81 | |
| Phenylalanine | 0.32 | 0.04 | 0.62 | 0.98 | |
| Phenylalanine) | 0.32 | 0.04 | 0.62 | 0.98 ) | 1.79 |
| Tyrosine ) | 0.27 | 0.03 | 0.51 | 0.81 ) | |
| Threonine | 0.25 | 0.03 | 0.49 | 0.77 | |
| Valine | 0.34 | 0.04 | 0.63 | 1.01 | |
| Histidine | 0.20 | 0.02 | 0.32 | 0.54 | |

Results and discussion of Experiment III.

In view of the foregoing experiments, a third experiment was carried out to determine the effectiveness of additional choline and vitamin A. The basal diet of experiments I and II was used with a .50% lysine preparation and no methionine was added. The basal diet was changed in rations 5 and 6 by completely replacing barley and millet with yellow corn in order to investigate its effect, as is shown in table (37). The results of the 7 weeks average weight and feed efficiency (feed/gain) and food consumption (feed/day) for the third experiment are shown in tables (43, 44, 45).

The results indicated that when choline was increased in ration 3 to the N.R.C. level while the methionine level remained constant, there was no significant increase in weight. The feed efficiency was lower. When vitamin A was added to ration 4, the weight was almost the same as in ration 3, while the feed efficiency was significantly higher. The metabolizable energy was $\pm$ 2700 Cal/kg in rations 2, 3 and 4 while it became $\pm$ 2800 Cal/kg in rations 5 and 6. The crude protein per cent remained unchanged at $\pm$ 23%*, $\pm$ 22%**, while the fiber content was lower by 1% in rations 5 and 6. The methionine content of both rations mentioned was decreased by .09*%, .08%**. These changes affected both growth and feed efficiency as is shown in table (47). This agrees with the findings of Baldini and Rosenberg (1956, 1957) where they concluded that the methionine requirement was not a fixed value but varied as a linear function of the energy content of the diet. It also confirms the findings of Hill et al.(1953) when they stated that methionine required for best efficiency of feed utilization is somewhat greater than that required for maximum growth. We can observe that the weight was slichtly higher and there was a significantly high feed efficiency. This finding confirms the previous results in experiments I and II. In ration 6 where the choline content was increased to N.R.C. level, weight increased slightly as is shown by the result of ration 3 of this experiment. This finding is similar to that of Quillin, Combs and Romoser (1961). Their work showed that the addition of methionine or choline was not significantly better than the addition of either one alone at the highest levels used.

The lysine content of all the rations was kept constant as is shown in table (37). It can in general be concluded from these results that choline is needed to complete the requirements, as is stated by the N.R.C., though addition choline in the presence of excess methionine did not affect growth.

---

* 0-4 weeks
** 4-7 weeks

Females in all the four experiments showed better response to lysine than males and this coincides with Scutze's finding (1958).

From the results of the grading of the carcass quality it was clear that high energy rations gave better quality and this agrees with March and Biely (1954).

The main point in experiment 3 was that replacing the quantity of barley entirely by corn did not give a better result even though the energy level increases, and this agrees with the finding of Arscott et al. (1958) when they concluded that barley can replace one half till three quarter of the ground corn. From the results of experiment 4 it was found that a uniform P/E ratio cannot readily be given irrespective of the energy level and protein quality.

This in agreement with the findings of Galet, Jovandet, Barabtou (1960, 1961) when they demonstrated that the optimum calorie/protein ratio varies with the nature of the dietary protein.

Testing the availability of zinc and the quantity of sodium in Experiment V showed that approximately 20 ppm zinc and 15% sodium is enough to satisfy the chicks' need for growth. This agrees with the N.R.C. (1960) requirements and it also coincides with the findings of O'Dell et al. (1958) about the zinc requirements.

In the biological determination of the amino acids in experiment VI using Albino rats, it was found that the amino acid threonine limited the protein value. However, when this was tried on chicks in experiments VII and VIII, it was found no longer to be the case. The biological value of the plant protein diet of this experiment was found to be 90%, if it is compared to the animal protein value of the same experiment. Applying the Bartlett-test for homogenity of the variation of growth to experiments 1, 2, 3, 4 and 5 it was shown that treatments did not cause the difference in variance. To check the possible differences in the slope of the growth curve, the growth over the experimental period was divided into 3 components (level, linear and quadratic component) and a test of significance for the differences was made. The results show that in all the experiments, both sexes (except the females of experiment I) are concerned. The (negative) quadratic component of the growth curves was slightly significantly lower in the plant protein groups than in the animal protein groups. ($P < 0.01$).

This indicates clearly that though in most cases growth was a bit slower in the early growth stages in the plant protein groups.

This lag was partly recovered in later stages. This leads to the conclusion that for the later growth stages the plant protein mixture was adequate.

Much lower variations in weights were attained in this experiment (the variation between the animal protein control group and other plant protein groups), although they are still of statistical significance and this can be seen in tables (48, 49).

At the end of the feeding trial of experiment III, all the birds were sent to the slaughter house (Pluimveeslachterij "WEZEP" , N.V.) to be scored and graded according to their commercial carcass quality. The results are given in table (42). The effect of higher quantities of corn on colour and flesh and of the higher energy level on the grading result can be observed. This is in agreement with the findings of experiment I.

TABLE 42.

Broiler carcass quality of Experiment III.

| Group No. | I | | II | | III | | IV | | V | | VI | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sex | M | F | M | F | M | F | M | F | M | F | M | F |
| Colour | 3.5 | 3.5 | 3.2 | 3.2 | 3.0 | 2.8 | 3.2 | 3.2 | 3.6 | 3.7 | 3.8 | 3.8 |
| Defect | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| Fleshing | 3.4 | 3.5 | 3.2 | 3.4 | 3.2 | 3.0 | 3.2 | 3.4 | 3.5 | 3.7 | 3.6 | 3.8 |
| Uniformity | 3.8 | 3.8 | 3.0 | 3.5 | 3.5 | 3.4 | 3.0 | 3.5 | 3.3 | 3.3 | 3.4 | 3.5 |
| Total | 3.2 | 3.2 | 2.9 | 3.1 | 3.0 | 2.8 | 2.9 | 3.1 | 3.2 | 3.2 | 3.2 | 3.3 |
| Total high quality | 3.5 | 3.6 | 3.1 | 3.4 | 3.2 | 3.1 | 3.1 | 3.4 | 3.5 | 3.6 | 3.6 | 3.7 |
| Grade | A | | B | | B | | B | | A | | A | |
| Classification | 2 | | 5 | | 6 | | 4 | | 3 | | 1 | |

TABLE (43).

Average weight (gr) of the Males and Females of Experiment III.

| Group No. | Rep. | Sex | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | week 7 |
|---|---|---|---|---|---|---|---|---|---|
| I | 4 | M | 92.75 | 200.75 | 342.75 | 537.25 | 767.75 | 997.25 | 1198.50 |
| | 4 | F | 92.75 | 189.50 | 313.75 | 477.75 | 670.25 | 857.50 | 1029.25 |
| II | 4 | M | 84.50 | 175.00 | 296.00 | 466.00 | 681.00 | 903.75 | 1113.25 |
| | 4 | F | 84.75 | 172.00 | 279.75 | 488.50 | 617.50 | 812.00 | 980.50 |
| III | 4 | M | 86.25 | 175.00 | 294.25 | 468.25 | 689.75 | 930.25 | 1133.75 |
| | 4 | F | 86.25 | 174.75 | 282.25 | 403.75 | 603.50 | 802.00 | 967.50 |
| IV | 4 | M | 87.50 | 176.50 | 298.75 | 464.75 | 685.75 | 905.75 | 1125.50 |
| | 4 | F | 84.50 | 169.75 | 283.25 | 416.00 | 611.50 | 800.25 | 976.50 |
| V | 4 | M | 88.00 | 177.75 | 294.50 | 461.00 | 676.50 | 911.50 | 1132.00 |
| | 4 | F | 85.25 | 172.50 | 282.25 | 416.50 | 613.00 | 792.25 | 978.25 |
| VI | 4 | M | 87.58 | 177.00 | 299.50 | 466.00 | 685.25 | 916.25 | 1136.75 |
| | 4 | F | 86.75 | 171.25 | 279.00 | 425.00 | 617.50 | 805.00 | 991.25 |

TABLE (44).

Average Cumulative Feed Efficiency of Experiment III.

| Group No. | Rep. | Sex | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | week 7 |
|---|---|---|---|---|---|---|---|---|---|
| I | 4 | M | 1.405 | 1.477 | 1.597 | 1.732 | 1.802 | 1.935 | 2.112 |
| | 4 | F | 1.395 | 1.527 | 1.665 | 1.747 | 1.825 | 1.960 | 2.130 |
| II | 4 | M | 1.547 | 1.655 | 1.750 | 1.827 | 1.867 | 2.000 | 2.157 |
| | 4 | F | 1.577 | 1.725 | 1.862 | 1.957 | 1.965 | 2.082 | 2.265 |
| III | 4 | M | 1.530 | 1.652 | 1.792 | 1.865 | 1.907 | 2.012 | 2.205 |
| | 4 | F | 1.537 | 1.690 | 1.852 | 2.055 | 2.017 | 2.095 | 2.282 |
| IV | 4 | M | 1.510 | 1.645 | 1.777 | 1.847 | 1.870 | 2.000 | 2.132 |
| | 4 | F | 1.475 | 1.647 | 1.780 | 1.945 | 1.950 | 2.067 | 2.242 |
| V | 4 | M | 1.427 | 1.632 | 1.827 | 1.877 | 1.852 | 1.955 | 2.092 |
| | 4 | F | 1.520 | 1.632 | 1.752 | 1.885 | 1.872 | 2.017 | 2.135 |
| VI | 4 | M | 1.602 | 1.650 | 1.767 | 1.807 | 1.835 | 1.950 | 2.085 |
| | 4 | F | 1.392 | 1.615 | 1.792 | 1.842 | 1.870 | 2.005 | 2.170 |

## TABLE (45).

Average Cumulative food consumption (gr) Food/day of Experiment III.

| Group No. | Rep. | Sex | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | week 7 |
|---|---|---|---|---|---|---|---|---|---|
| I | 4 | M | 10.48 | 23.37 | 35.40 | 54.16 | 64.37 | 77.44 | 84.53 |
| | 4 | F | 10.47 | 22.09 | 32.61 | 44.27 | 55.14 | 64.73 | 72.07 |
| II | 4 | M | 9.98 | 21.91 | 31.91 | 47.38 | 60.16 | 75.82 | 84.36 |
| | 4 | F | 9.93 | 22.46 | 31.31 | 44.84 | 53.75 | 67.41 | 75.27 |
| III | 4 | M | 9.80 | 21.86 | 33.33 | 49.24 | 63.22 | 78.94 | 88.59 |
| | 4 | F | 10.25 | 22.17 | 31.60 | 41.71 | 56.78 | 66.22 | 74.02 |
| IV | 4 | M | 10.21 | 21.79 | 33.16 | 46.24 | 60.65 | 74.91 | 83.52 |
| | 4 | F | 9.52 | 21.24 | 31.29 | 42.86 | 54.93 | 65.71 | 75.45 |
| V | 4 | M | 9.71 | 22.31 | 34.37 | 46.39 | 55.84 | 74.67 | 83.43 |
| | 4 | F | 10.01 | 21.15 | 29.84 | 40.96 | 51.79 | 63.95 | 69.10 |
| VI | 4 | M | 10.47 | 21.69 | 33.36 | 44.66 | 59.41 | 74.61 | 82.81 |
| | 4 | F | 9.55 | 21.15 | 30.98 | 40.17 | 53.12 | 65.17 | 75.62 |

## TABLE (46).

Chicks mortality record of Experiment III.

| Sex | Control Group I | Group II | Group III | Group IV | Group V | Group VI |
|---|---|---|---|---|---|---|
| M | 3 | 3 | 2 | 2 | 2 | 3 |
| F | 4 | 3 | 3 | 2 | 3 | – |
| Total | 7 | 6 | 5 | 4 | 5 | 3 |

TABLE (47).

Body weight and feed conversion of Experiment III.

| Group No. | Treatment | Av. 7th week body wt. for both sexes (gr) | 7th week Av. feed conv. for both sexes (gr) |
|---|---|---|---|
| 1 | Animal protein + All. N.R.C. req. | 1113.88 | 2.121 |
| 2 | plant protein + Total lysine [.97%* / .95%**] + Total methionine [1.07% / 1.00%] + Total choline [1137 mg/kg / 1123 mg/kg] + 4% vegetable oil | 1046.88 | 2.211 |
| 3 | plant protein + Total lysine [.97% / .95%] + Total methionine [1.07% / 1.00%] + Total choline [1320 mg/kg / 1320 mg/kg] + 4% vegetable oil | 1050.63 | 2.244 |
| 4 | plant protein + Total lysine [.97% / .95%] + Total methionine [1.17% / 1.10%] + Total choline [1320 mg/kg / 1320 mg/kg] + 4% vegetable oil + 2250 I.U. vit. A | 1051.00 | 2.187 |
| 5 | plant protein + Total lysine [.97% / .94%] + Total methionine [1.08% / 1.02%] + Total choline [1137 mg/kg / 1123 mg/kg] + 4% vegetable oil | 1055.13 | 2.114 |
| 6 | plant protein + Total lysine [.97% / .94%] + Total methionine [1.08% / 1.02%] + Total choline [1320 mg/kg / 1320 mg/kg] + 4% vegetable oil | 1064.00 | 2.128 |

* From 0-4 weeks
** From 4-7 weeks

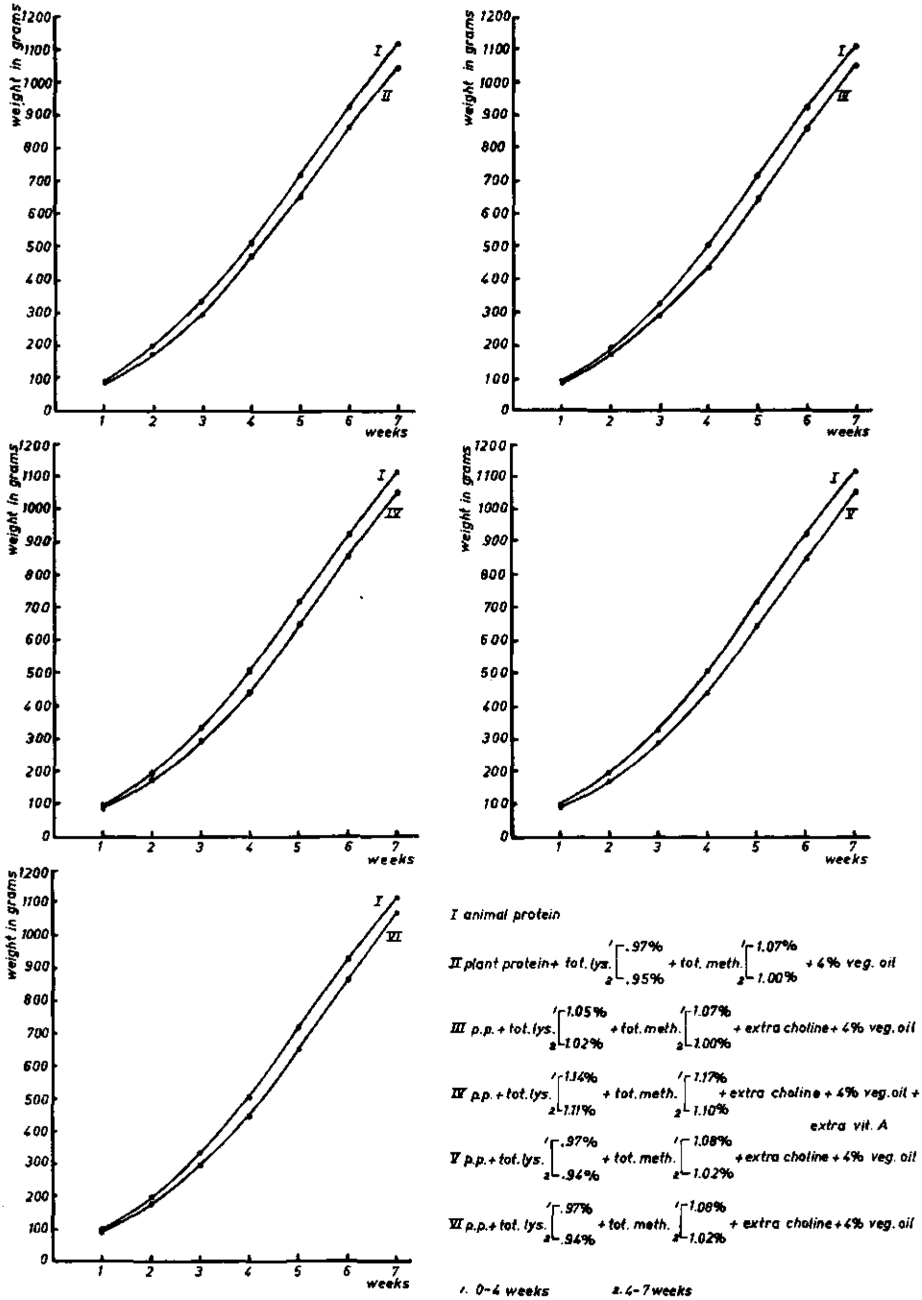


Fig. 5. Comparison between animal protein diet and plant protein diets supplemented with choline and vitamin A, and the effect of these supplements on chicks' at 7 weeks. Exp. III.

TABLE (48).

Average weight of chicks in Experiment III.

| | Sex | Gr. 1 | Gr. 2 | Gr. 3 | Gr. 4 | Gr. 5 | Gr. 6 |
|---|---|---|---|---|---|---|---|
| 7th week weight | M | 1198.50 | ** 1113.25 | ** 1133.75 | ** 1125.50 | ** 1132.00 | ** 1136.75 |
| (gr) | F | 1029.25 | ** 980.50 | ** 967.50 | ** 976.50 | ** 978.25 | ** 991.25 |

* P < .05
** P < .01

TABLE (49).

Average cumulative feed efficiency of Experiment III.

| | Sex | Gr. 1 | Gr. 2 | Gr. 3 | Gr. 4 | Gr. 5 | Gr. 6 |
|---|---|---|---|---|---|---|---|
| 7th week Cu. F. | M | 2.112 | * 2.157 | ** 2.050 | 2.132 | 2.092 | 2.085 |
| efficiency | F | 2.130 | ** 2.265 | ** 2.282 | ** 2.242 | 2.135 | 2.170 |

* P < .05
** P < .01

## Experiment IV.

A knowledge of the available energy content and of the relationship between energy and protein level is an important consideration in formulating the most economical rations. For this reason experiment IV was conducted with varying crude protein levels from + 20.5% to + 24.5%, and varying metabolizable energy levels from + 2700 Cal/kg to + 3200 Cal/kg.

Ingredients used in this diet were the same as in experiments I, II, III, but in a different combination as presented in table (52). The lysine quantity was 1.2% of the protein content of the diets 6, 7, 8, 9, 10, 11 and 12.

### Stock and Management.

Stock and management of this experiment was almost the same as in the previous one, but the number of chicks was 912, divided into 12 groups and placed in (48) lots, 24 for each sex, with (19) chicks in each lot as is shown in table (50).

TABLE 50.

Random Selection Table

| Group | Lot No. Male | | Lot No. Male | |
|---|---|---|---|---|
| 1 | 9 | 29 | 3 | 46 |
| 2 | 22 | 33 | 11 | 27 |
| 3 | 1 | 34 | 15 | 45 |
| 4 | 19 | 31 | 17 | 26 |
| 5 | 10 | 28 | 23 | 38 |
| 6 | 6 | 39 | 16 | 44 |
| 7 | 5 | 32 | 18 | 35 |
| 8 | 4 | 36 | 14 | 47 |
| 9 | 20 | 42 | 2 | 25 |
| 10 | 7 | 37 | 24 | 30 |
| 11 | 8 | 40 | 21 | 48 |
| 12 | 12 | 41 | 13 | 43 |

### Experimental diets.

Experiment IV was designed to study the relationship between energy and protein in different levels in order to find the best combination for the(sesame-corn-barley). 12 diets were formulated as follows:

Diet 1 = Animal protein [± 24%* / ± 21%**] + [± 3200 Cal/kg / ± 3100 Cal/kg] (same as Exp. III).

Diet 2 = Diet 1 + 10% crude protein [± 26%* / ± 23%**] + [± 3200* Cal/kg / ± 3100** Cal/kg]

Diet 3 = Diet 1 - 10% crude protein [± 21.5%* / ± 20.5%**] + [± 3200* Cal/kg / ± 3100** Cal/kg]

Diet 4 = Plant protein. Sesame Meal (same sample as in Exp. II + 1% lysine + ± 2700 Cal/kg.

Diet 5 = Plant protein (sesame). New sample (expeller) + 1% lysine + ± 2700 Cal/kg.

Diet 6 = Diet 5 + 1.2% total lysine.
Diet 7 = Diet 6 + 10% crude protein.
Diet 8 = Diet 6 - 10% crude protein.
Diet 9 = Diet 6 + 3% alfalfa meal only.

Diet 10 = Diet 9 with ME*** [± 3200 Cal/kg / ± 3100 Cal/kg]

Diet 11 = Diet 10 + 10% crude protein.
Diet 12 = Diet 10 - 10% crude protein.

Compositions of the diets have been calculated. Details of the experimental rations are shown in the following tables.

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* 0-4 weeks.
** 4-7 weeks.
*** Metabolizable energy.

TABLE 51.

Average analyses of feed ingredients of Experiment IV.*

| Nutrient | % Protein | % Fiber | % Fat | % N Free Extr. | % Moisture | % Ash | % Ca | % P |
|---|---|---|---|---|---|---|---|---|
| Barley | 12.3 | 5.8 | 2.2 | 65.2 | 11.8 | 2.7 | 0.05 | 0.33 |
| Oats | 10.3 | 8.1 | 5.4 | 60.2 | 14.3 | 1.9 | 0.08 | 0.37 |
| Cottonseed Meal | 40.5 | 11.8 | 5.1 | 29.8 | 6.4 | 6.4 | 0.24 | 1.15 |
| Alfalfa | 14.6 | 25.5 | 2.7 | 36.2 | 11.5 | 9.5 | 1.34 | 0.20 |
| Y. Corn | 9.2 | 3.0 | 4.0 | 69.1 | 13.4 | 1.3 | 0.03 | 0.25 |
| Millet | 12.2 | 8.2 | 3.7 | 61.0 | 11.2 | 3.7 | 0.03 | 0.33 |
| Milo | 9.2 | 2.0 | 3.0 | 71.2 | 13.0 | 1.6 | 0.03 | 0.34 |
| Sesame (Expeller)** | 36.8 | 5.6 | 9.0 | 26.1 | 8.8 | 13.7 | 2.86 | 1.06 |
| Sesame (Expeller)*** | 42.0 | 4.5 | 6.4 | 21.7 | 7.5 | 17.9 | 1.94 | .84 |
| Soybean cake meal | 46.5 | 5.9 | 0.8 | 28.1 | 12.7 | 6.0 | 0.29 | 0.64 |
| Wheat | 10.7 | 2.7 | 2.0 | 66.8 | 16.3 | 1.5 | 0.04 | 0.28 |
| Sunflower C.M. | 40.1 | 16.6 | 2.2 | 26.1 | 7.7 | 7.3 | 0.39 | 1.10 |
| Sesame oil meal | 48.9 | 7.1 | 0.8 | 21.7 | 11.2 | 10.3 | 2.00 | 1.44 |
| Meat meal | 59.1 | 0.0 | 7.9 | 0.0 | 10.1 | 20.7 | 5.36 | 2.56 |
| Fish Meal Herring 75% | 75.8 | 0.0 | 9.5 | 0.0 | 6.2 | 9.9 | 1.83 | 1.72 |
| Whey Powder | 11.9 | 0.0 | 0.1 | 74.5 | 5.1 | 8.4 | 0.6 | 0.65 |
| Vit. B filler | 17.4 | 6.9 | 4.4 | 53.7 | 13.0 | 4.6 | 0.17 | 0.95 |

* The analysis carried out at the Central Institute for Poultry Research Lab. "Het Spelderholt".
** used from 0 - 4 weeks.
*** used from 4 - 7 weeks.

TABLE (52).

Diets and Plan - Experiment IV.

| Ingridient | Diet 1 | | Diet 2 | | Diet 3 | | Diet 4 1% lys. | | Diet 5 1% lys. | | Diet 6 1.2% lys. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 |
| Y.Corn. | 43 | 47.5 | 43 | 43 | 47.5 | 48.5 | 30 | 30 | 30 | 30 | 30 | 30 |
| Milo | 5 | 5 | 5 | 5 | 5 | 5 | - | - | - | - | - | - |
| Oat | 5 | 5 | 5 | 5 | 5 | 5 | - | - | - | - | - | - |
| Wheat | 5 | 5 | 1 | 4.5 | 5 | 5 | - | - | - | - | - | - |
| Soybean Meal | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9 | - | - | - | - | - | - |
| Sesame (Expeller)(1) | 3 | 3 | 3 | 3 | 3 | 3 | - | - | 47 | 36 | 46 | 36 |
| Sunflower meal | 3 | 3 | 3 | 3 | 3 | 3 | - | - | - | - | - | - |
| Cottonseed meal | 2 | - | 2 | 2 | - | - | - | - | - | - | - | - |
| Alfalfa meal | 2 | 2 | 2 | 2 | 2 | 2 | 5 | 5 | 5 | 5 | 5 | 5 |
| Meat meal | 2 | 2 | 2 | 2 | 2 | 2 | - | - | - | - | - | - |
| Wheypowder | 3 | 3 | 3 | 3 | 3 | 3 | - | - | - | - | - | - |
| Minerals | 2 | 2.5 | 2 | 2 | 2.5 | 2 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Vital | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Fish meal | 11 | 8 | 15 | 11.5 | 8 | 8 | - | - | - | - | - | - |
| Hydan | 0.1 | - | - | 0.1 | - | 0.1 | - | - | - | - | - | - |
| Animal fat | 3 | 3 | 3 | 3 | 3 | 3 | - | - | - | - | - | - |
| Vit A/D3 prep. | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.13 | 0.12 | 0.13 | 0.12 | 0.13 | 0.12 |
| Vit B12 prep. | - | - | - | - | - | - | + | + | + | + | + | + |
| Barley | - | - | - | - | - | - | 18 | 22 | 15 | 20 | 15 | 20 |
| Millet | - | - | - | - | - | - | 10 | 10 | 5 | 6 | 6 | 6 |
| Sesame oil meal | - | - | - | - | - | - | 34 | 30 | - | - | - | - |
| Lysine prep. | - | - | - | - | - | - | 0.5 | 0.5 | 0.47 | 0.42 | 0.72 | 0.65 |
| Sesame oil | - | - | - | - | - | - | 4 | 4 | - | 3 | - | 3 |
| Total | 100.22 | 100.12 | 100.12 | 100.22 | 100.12 | 100.22 | 104.63 | 104.62 | 105.60 | 103.54 | 105.85 | 103.77 |
| Crude protein% | ±24 | 21 | ±26 | ±23 | ±21.5 | ±20.5 | ±22.5 | ±21.5 | ±22.5 | ±21.5 | ±22.5 | ±21.5 |
| Digestible protein% | ±19.5 | 17.5 | ±22 | ±20 | ±17 | ±17 | ±19 | ±18 | ±19 | ±18 | ±19 | ±18 |
| Metabolozable Energy Cal/kg | ±3200 | ±3100 | ±3200 | ±3100 | ±3200 | ±3100 | ±2700 | ±2700 | ±2700 | ±2700 | ±2700 | ±2700 |

TABLE (52).

Diets and Plan - Experiment IV.

| Diet 7 1.2% lys. | | Diet 8 1.2% lys | | Diet 9 1.2% lys | | Diet 10 1.2% lys. | | Diet 11 1.2% lys | | Diet 12 1.2% lys. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 |
| 20 | 26 | 30 | 30 | 30 | 30 | 30 | 30 | 28.5 | 30 | 30 | 30 |
| - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - |
| 55 | 44 | 38 | 28 | 47 | 36 | 50 | 38 | 59.5 | 45 | 40 | 30 |
| - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - |
| 5 | 5 | 5 | 5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - |
| 0.13 | 0.12 | 0.13 | 0.12 | 0.13 | 0.12 | 0.13 | 0.12 | 0.13 | 0.12 | 0.13 | 0.12 |
| + | + | + | + | + | + | + | + | + | + | + | + |
| 15 | 15 | 20 | 20 | 15 | 20 | 6 | 10.5 | - | 4 | 8 | 15 |
| 6 | 8 | 9 | 14 | 8 | 8 | 6 | 8 | 2 | 8 | 7 | 12.5 |
| - | - | - | - | - | - | - | - | - | - | - | - |
| 0.85 | 0.72 | 0.66 | 0.57 | 0.78 | 0.70 | 0.82 | 0.70 | 0.80 | 0.79 | 0.66 | 0.60 |
| - | 3.50 | -- | 1.50 | - | 2 | 8.5 | 9.5 | 9 | 10.0 | 8.5 | 8.5 |
| 104.98 | 105.34 | 105.79 | 102.19 | 106.91 | 102.82 | 107.45 | 102.82 | 105.93 | 103.91 | 100.29 | 102.72 |
| ±24.5 | ±23.5 | ±20.5 | ±19.5 | ±22.5 | ±21.5 | ±22.5 | ±21.5 | ±24.5 | ±23.5 | ±20.5 | ±19.5 |
| ±21 | ±20 | ±17 | ±16 | ±19 | ±18 | ±19 | ±18 | ±21 | ±20 | ±17 | ±16 |
| ±2700 | ±2700 | ±2700 | ±2700 | ±2700 | ±2700 | ±3200 | ±3100 | ±3200 | ±3100 | ±3200 | ±3100 |

TABLE (53).

Calculated Compositions of the Experiment IV.

| Nutrient | Diet 5 | | Diet 6 | | Diet 7 | | Diet 8 | | Diet 9 | | Diet 10 | | Diet 11 | | Diet 12 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 |
| Crude Protein% | +22.5 | +21.5 | +22.5 | +21.5 | +24.5 | +23.5 | +20.5 | +19.5 | +22.5 | +21.5 | +22.5 | +21.5 | +24.5 | +23.5 | +20.5 | +19.5 |
| Dig. Protein% | +19 | +18 | +19 | +18 | +21 | +20 | +17 | +16 | +19 | +18 | +19 | +18 | +21 | +20 | +17 | +16 |
| Metabolizable E. Cal/kg | +2700 | +2700 | +2700 | +2700 | +2700 | +2700 | +2700 | +2700 | +2700 | +2700 | +3200 | +3100 | +3200 | +3100 | +3200 | +3100 |
| Fat | 5.75 | 7.04 | 5.69 | 7.02 | 6.12 | 7.69 | 5.22 | 5.45 | 5.73 | 6.14 | 13.61 | 13.35 | 14.76 | 13.98 | 13.76 | 12.16 |
| Fiber | 5.76 | 5.25 | 5.76 | 5.24 | 5.01 | 5.27 | 5.84 | 5.61 | 5.43 | 4.95 | 4.92 | 4.49 | 4.81 | 4.39 | 4.92 | 4.77 |
| (1) Amino acids | | | | | | | | | | | | | | | | |
| Lysine | .95 | .89 | 1.11 | 1.06 | 1.28 | 1.16 | 1.02 | .96 | 1.14 | 1.09 | 1.14 | 1.07 | 1.20 | 1.16 | 1.03 | .93 |
| Methionine + Cystine | 1.02 | .95 | .95 | .94 | 1.13 | 1.08 | .90 | .85 | 1.03 | .97 | 1.00 | .96 | 1.12 | 1.05 | .93 | .83 |
| Arginine | 2.20 | 2.05 | 2.16 | 2.04 | 2.50 | 2.33 | 1.88 | 1.71 | 2.17 | 2.05 | 2.23 | 2.08 | 2.59 | 2.36 | 1.97 | 1.71 |
| Tryptophan | .27 | .26 | .26 | .26 | .30 | .29 | .25 | .24 | .28 | .28 | .26 | .26 | .28 | .27 | .24 | .22 |
| Glycine | 1.01 | .95 | .99 | .94 | 1.11 | 1.04 | .89 | .82 | 1.00 | .94 | .99 | .94 | 1.10 | 1.03 | .89 | .80 |
| Isoleucine | .78 | .75 | .77 | .75 | .85 | .82 | .71 | .68 | .78 | .76 | .76 | .75 | .83 | .80 | .70 | .65 |
| Leucine | 1.57 | 1.53 | 1.56 | 1.52 | 1.66 | 1.63 | 1.47 | 1.45 | 1.57 | 1.55 | 1.53 | 1.52 | 1.64 | 1.59 | 1.45 | 1.37 |
| Phenylalanine + Tyrosine | 1.74 | 1.67 | 1.74 | 1.67 | 1.91 | 1.82 | 1.60 | 1.52 | 1.74 | 1.68 | 1.70 | 1.64 | 1.88 | 1.77 | 1.58 | 1.44 |
| Threonine | .76 | .72 | .75 | .72 | .83 | .79 | .69 | .66 | .75 | .73 | .74 | .71 | .81 | .77 | .68 | .62 |
| Valine | .93 | .90 | .92 | .90 | 1.03 | 1.00 | .83 | .77 | .90 | .89 | .89 | .86 | 1.01 | .94 | .81 | .74 |
| Histidine | .56 | .54 | .51 | .54 | .58 | .52 | .51 | .50 | .56 | .54 | .56 | .53 | .60 | .58 | .52 | .48 |
| Minerals | | | | | | | | | | | | | | | | |
| Calcium% | 1.74 | 1.16 | 1.71 | 1.15 | 1.97 | 1.28 | 1.50 | 1.02 | 1.70 | 1.14 | 1.76 | 1.17 | 2.04 | 1.29 | 1.61 | 1.03 |
| Phosphorus% | .64 | .58 | .72 | .57 | .79 | .61 | .67 | .54 | .63 | .58 | .72 | .57 | .79 | .60 | .68 | .53 |
| Sodium% (3) | .22 | .21 | .22 | .20 | .24 | .22 | .21 | .19 | .22 | .20 | .22 | .20 | .24 | .22 | .21 | .19 |
| K.% (3) | .80 | .71 | .79 | .71 | .87 | .76 | .72 | .62 | .75 | .68 | .74 | .66 | .83 | .70 | .69 | .59 |
| Zinc P.P.M (3) | 38.41 | 37.88 | 38.35 | 37.84 | 38.14 | 37.64 | 38.27 | 37.94 | 37.97 | 37.62 | 36.64 | 36.38 | 36.64 | 36.32 | 36.56 | 36.44 |

(1) Please see Chap. II. (Amino acid assay).
(2) From 4-7 weeks the protein level was reduced.
(3) Taken from Tituts and Ewing.

TABLE 54.

Calculated Compositions of the Experiment IV.

| Nutrient | Diet 5 |  | Diet 6 |  | Diet 7 |  | Diet 8 |  | Diet 9 |  | Diet 10 |  | Diet 11 |  | Diet 12 |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 | 0-4 | 4-7 |
| Vit. A U.S.P.U. P/kg | 13363 | 13374 | 13331 | 13345 | 13028 | 12992 | 13336 | 13769 | 9776 | 9901 | 9675 | 9851 | 9742 | 9753 | 10314 | 9865 |
| Riboflavin Mg/kg | 5.59 | 5.48 | 5.58 | 5.46 | 5.79 | 5.58 | 5.52 | 5.60 | 5.35 | 5.31 | 5.23 | 5.23 | 5.34 | 5.30 | 5.36 | 5.22 |
| Pantothenic acid Mg/kg | 11.78 | 11.89 | 11.79 | 11.87 | 11.82 | 11.70 | 12.00 | 12.33 | 11.35 | 11.59 | 10.64 | 10.98 | 10.43 | 10.76 | 11.09 | 11.30 |
| Choline Mg/kg + additive | 1218 | 1287 | 1212 | 1289 | 1309 | 1277 | 1185 | 1341 | 1221 | 1298 | 1141 | 1289 | 1178 | 1290 | 1107 | 1145 |
| Niacin Mg/kg | 33.19 | 35.47 | 33.23 | 35.42 | 32.38 | 32.85 | 35.59 | 37.02 | 33.37 | 35.17 | 28.72 | 31.56 | 25.93 | 28.67 | 31.04 | 34.10 |
| Thiamine Mg/kg | 33.19 | 3.66 | 2.70 | 3.65 | 3.52 | 3.59 | 3.84 | 4.05 | 3.71 | 3.36 | 3.27 | 3.41 | 2.99 | 3.29 | 3.37 | 3.70 |

## Experiment IV.

### Results and Discussion of Experiment IV.

It was found necessary to study the effects of various protein and energy levels on the growth rate and feed efficiency in order to acquire a complete picture of the plant protein value. For this reason 12 different rations were formulated; the first three were animal protein rations with different protein levels, and the other 9 plant protein rations were formed with different protein and metabolizable energy levels, as is shown in table (52).

The 7th week average weight, feed efficiency and food consumption for this experiment are shown in tables (57,58,59)

Considering diets 1,2 and 3, where animal protein had been used in different levels with fixed metabolizable energy level ± 3200* - ± 3100** Cal/kg, the result indicate that the higher protein level 26% produced the best growth. This can be observed in diet No. 2. Reduction of the crude protein from 26% to 24% resulted in less growth and a slight decrease in feed efficiency as is shown by diet No. 3.

When the crude protein was reduced to 21%, a further decrease took place in both weight and feed efficiency.

This corroborated the findings of Scott er al. (1947), Matterson (1950), Sunde (1956), Matterson et al. (1955,1957), when they demonstrated that high energy and protein in the diet permitted broilers to grow more rapidly and use their feed more efficiently. Diet 4 contained sesame oil meal while diet 5 content sesame expeller meal from a different batch.

It was shown very clearly in this experiment that this sesame oil meal was better for chicks, possibly because of the high calcium content of the sesame expeller. For this reason it was advisable in the second stage of this experiment from (4-7) weeks to change to a sesame expeller with a lower calcium content, as is shown in table (51).

Approximately 1.2 per cent of lysine, when added to diet 6 with a fixed energy and protein level, improved growth significantly as compared with diet 5, and this result comfirms the precious findings in experiment I and II.

In diet 7, where the crude protein level was increases to 24.5%* - 23.5%** or in diet 8 where the crude protein level was decreased to 20.5%*- 19.5%** with a fixed metabolizable energy of ± 2700 it was found that the growth and feed efficiency were significantly lowered in comparison to diet 6 and this confirms the findings of Sunde (1956), Hill and Dansky (1950) VIZ. that growth was reduced when a high energy diet with a low protein content was fed.

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* 0-4 weeks

** 4-7 weeks

In diet 9 where the percentage of alfalfa meal was reduced from 5 to 3% growth was reduced significantly. This agrees with Janssen's statement (1960) that the quantity of alfalfa meal to be used in broiler rations depends on the fiber content and the duration between cutting and using. In diets 10, 11 and 12 where the metabolizable energy was increased from ± 2700 Cal/kg to ± 3200*, ± 3100** Cal/kg and different protein levels were used, there was no improvement in growth but the feed efficiency was better and this confirms the findings of Henderson and Irwin (1940), Siedler and Schweigert (1953), Sunde (1954), Runnels (1954) and Donaldson et al., (1954) where they reported that additive fat can improve feed efficiency but not growth. The crude protein level in diets 10,11, and 12 was 22.5%, 24.5%, 20.5% respectively and the results as obtained in diets 6, 7 and 8 can be observed here too. Also where a high energy level and low level of protein was applied, growth was depressed.

The different MC/P ratio and its effect can be noted in table (55). When the MC/P ratio was 55:1*-57:1**, the best growth was obtained with crude plant protein rations, while with the crude animal protein rations the best ratio was 55:1* -59:1** MC/P/lb. and it seems that the best MC/P ratio differs with the energy level and protein quality in the ration.

It was found that with a low energy level the MC/P was 55:1 while it was 65:1 at a high energy level with the same protein quality. In animal protein diets with a high energy level and high protein level the best MC/P ratio was found to be 55:1, from this result it is questionable wether a uniform P/E ratio can be given irrespective of the energy level and protein quality. And this agrees with Calet, Jovandet,Barantou (1960, 1961) when they demonstrated that the optimal amount of calories per gram of protein ingested is related to the nature of the dietary protein efficiency. They also show clearly that the optimum calory/protein ratio varies with the nature of the dietary protein.

The lysine content of the rations 6, 7, 8, 9, 10, 11 and 12 was approximately 1.2%. It is difficult to give the exact figures but we can say that approximately 1.2% was sufficient to give good results from the (sesame-corn.barley) diet in this experiment. This is in agreement with the findings of Day (1964), that the amino acid requirements cannot be stated very accurately in terms of a certain percentage of crude protein or as a ratio between protein and energy, since variation in protein quality is the big factor involved.

It can in general be concluded from the total data that the difference in weight between the animal protein diet

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* 0-4 weeks
** 4-7 weeks

chicks and the plant protein diet chicks (supplemented with lysine) is not so high, though it is still statistical significance there, and this can be seen in tables (61, 62). The mortality percentage was low in all rations as is shown in table (60).

At the end of the feeding trial of experimant IV, all the birds were sent to the slaghterhouse (Pluimveeslachterij "WEZEP", N.V.) to be scored and graded according to their commercial carcass quality. The results are given in table (56). From these results it can be seen that the birds in groups 1, 2, 3, 4, 5, 6 and 7 were scored as top quality, while the birds in group 8 failed to produce good flesh and uniformity as the other seven had done.

This may be due to the low protein level. Birds in group 9 showed the same defects as in group 8; no reason can be given unless we suggest that it was because less alfalfa had been applied in the diet of this group. Groups 10 and 11 yielded high quality meat due to their high energy level and this confirms the findings of experiments I and II.

Group 12 showed less fleshing and uniformity and it seems that this is due to the low protein high energy level, which has already been discussed.

TABLE (55).

MC/P/lb. for crude and digestable protein content of diet IV.

| Group | crude protein 0-4 | crude protein 4-7 | crude p. M/C/P/lb 0-4 | crude p. M/C/P/lb 4-7 | Digestable protein 0-4 | Digestable protein 4-7 | Digestable p. MC/P/lb 0-4 | Digestable p. MC/P/lb 4-7 | Av. weight of 7 weeks for both sexes (gr) | Av.cum.efficiency of the 7th week for both sexes |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ±24.0 | ±21.5 | 62:1 | 66:1 | ±19.5 | ±17.5 | 74:1 | 80:1 | 1034.25 | 2.197 |
| 2 | ±26.0 | ±24.0 | 55:1 | 59:1 | ±22.0 | ±20.0 | 66:1 | 70:1 | 1050.25 | 2.155 |
| 3 | ±21.0 | ±20.5 | 70:1 | 68:1 | ±17.0 | ±17.0 | 85:1 | 83:1 | 1019.50 | 2.195 |
| 4 | ±22.5 | ±21.5 | 55:1 | 57:1 | ±19 | ±18 | 65:1 | 69:1 | 972.75 | 2.302 |
| 5 | ±22.5 | ±21.5 | 55:1 | 57:1 | ±19 | ±18 | 65:1 | 69:1 | 886.00 | 2.435 |
| 6 | ±22.5 | ±21.5 | 55:1 | 57:1 | ±19 | ±18 | 65:1 | 69:1 | 959.00 | 2.450 |
| 7 | ±24.5 | ±23.5 | 50:1 | 52:1 | ±21 | ±20 | 58:1 | 61:1 | 909.25 | 2.427 |
| 8 | ±20.5 | ±19.5 | 60:1 | 63:1 | ±17 | ±16 | 72:1 | 77:1 | 924.75 | 2.435 |
| 9 | ±22.5 | ±21.5 | 55:1 | 57:1 | ±19 | ±18 | 66:1 | 69:1 | 921.00 | 2.485 |
| 10 | ±22.5 | ±21.5 | 65:1 | 66:1 | ±19 | ±18 | 77:1 | 78:1 | 940.25 | 2.155 |
| 11 | ±24.5 | ±23.5 | 60:1 | 60:1 | ±21 | ±20 | 69:1 | 70:1 | 915.00 | 2.120 |
| 12 | ±20.5 | ±19.5 | 70:1 | 72:1 | ±17 | ±16 | 85:1 | 88:1 | 902.00 | 2.167 |

## TABLE (56).

Broilers carcass quality of Experiment IV.

| Group | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | | 11 | | 12 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sex | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| Colour | 3.6 | 3.6 | 3.6 | 3.6 | 3.4 | 3.4 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.5 | 3.5 | 3.6 | 3.6 | 3.5 | 3.5 | 3.5 | 3.5 |
| Defects | 3.5 | 3.5 | 3.5 | 3.5 | 3.4 | 3.4 | 3.5 | 3.5 | 3.6 | 3.6 | 3.5 | 3.5 | 3.5 | 3.5 | 3.6 | 3.6 | 3.4 | 3.4 | 3.6 | 3.6 | 3.5 | 3.5 | 3.4 | 3.4 |
| Fleshing | 3.6 | 3.6 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.6 | 3.6 | 3.5 | 3.5 | 3.4 | 3.4 | 2.8 | 2.8 | 2.6 | 2.6 | 3.6 | 3.5 | 3.6 | 3.6 | 3.3 | 3.3 |
| Uniformity | 3.5 | 3.5 | 3.5 | 3.5 | 3.3 | 3.3 | 3.4 | 3.4 | 3.6 | 3.6 | 3.5 | 3.5 | 3.4 | 3.4 | 3.0 | 3.0 | 2.8 | 2.8 | 3.5 | 3.5 | 3.5 | 3.5 | 2.6 | 2.6 |
| Total | 3.6 | 3.6 | 3.6 | 3.6 | 3.4 | 3.4 | 3.5 | 3.5 | 3.6 | 3.6 | 3.5 | 3.5 | 3.4 | 3.4 | 3.1 | 3.1 | 2.4 | 2.4 | 3.6 | 3.5 | 3.5 | 3.5 | 3.4 | 3.4 |
| Total High quality | 3.6 | 3.6 | 3.6 | 3.6 | 3.4 | 3.4 | 3.5 | 3.5 | 3.6 | 3.6 | 3.6 | 3.6 | 3.4 | 3.4 | 3.2 | 3.2 | 2.9 | 2.9 | 3.3 | 3.5 | 2.3 | 2.3 | 2.2 | 2.2 |
| Grade | A | | A | | A | | A | | A | | A | | A | | B | | B | | A | | B | | C | |
| Classification | 2 | | 3 | | 6 | | 5 | | 1 | | 4 | | 7 | | 8 | | 9 | | 10 | | 11 | | 12 | |

TABLE (57).

Average cumulative food consumption (gr) Food/day of Experiment IV (males).

| Group | Rep. | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | week 7 |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 9.00 | 15.55 | 22.83 | 28.86 | 33.80 | 41.25 | 46.73 |
| 2 | 2 | 9.20 | 15.50 | 22.48 | 29.55 | 33.55 | 40.44 | 46.44 |
| 3 | 2 | 9.01 | 15.78 | 22.74 | 28.89 | 32.70 | 39.03 | 44.75 |
| 4 | 2 | 8.83 | 14.75 | 21.36 | 28.38 | 32.21 | 38.74 | 44.35 |
| 5 | 2 | 9.91 | 15.07 | 20.96 | 27.27 | 31.62 | 38.18 | 43.59 |
| 6 | 2 | 8.27 | 14.65 | 23.08 | 30.54 | 34.70 | 41.22 | 47.57 |
| 7 | 2 | 8.27 | 13.43 | 19.98 | 26.73 | 30.67 | 37.12 | 42.69 |
| 8 | 2 | 9.12 | 15.27 | 22.35 | 29.46 | 33.05 | 39.45 | 45.29 |
| 9 | 2 | 9.25 | 14.95 | 21.93 | 29.74 | 33.37 | 39.82 | 46.07 |
| 10 | 2 | 8.46 | 13.67 | 19.11 | 25.02 | 28.68 | 34.72 | 40.26 |
| 11 | 2 | 7.32 | 12.30 | 17.81 | 22.81 | 26.43 | 32.14 | 37.27 |
| 12 | 2 | 8.36 | 13.27 | 19.12 | 25.33 | 28.47 | 34.31 | 40.09 |

Average cumulative food consumption (gr) Food/day of Experiment IV (females)

| Group | Rep. | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | week 7 |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 9.02 | 15.50 | 22.05 | 28.42 | 32.81 | 37.65 | 42.39 |
| 2 | 2 | 9.58 | 15.50 | 22.24 | 28.47 | 31.68 | 37.55 | 41.93 |
| 3 | 2 | 9.32 | 15.17 | 21.61 | 28.59 | 31.16 | 37.43 | 42.27 |
| 4 | 2 | 8.64 | 14.56 | 21.05 | 27.44 | 31.39 | 38.15 | 42.31 |
| 5 | 2 | 8.45 | 13.99 | 20.17 | 26.68 | 30.03 | 35.80 | 40.54 |
| 6 | 2 | 8.52 | 14.75 | 21.70 | 29.25 | 32.30 | 38.55 | 43.46 |
| 7 | 2 | 8.30 | 14.09 | 20.77 | 27.83 | 31.25 | 37.26 | 42.33 |
| 8 | 2 | 9.58 | 15.12 | 21.61 | 28.56 | 32.55 | 34.61 | 42.72 |
| 9 | 2 | 7.91 | 12.79 | 20.69 | 27.21 | 30.88 | 36.88 | 41.33 |
| 10 | 2 | 7.33 | 12.06 | 18.18 | 24.10 | 28.03 | 33.91 | 38.27 |
| 11 | 2 | 7.35 | 12.10 | 17.84 | 24.18 | 28.17 | 32.10 | 36.79 |
| 12 | 2 | 8.11 | 12.46 | 17.57 | 23.02 | 26.02 | 31.65 | 36.17 |

TABLE (58).

Average cumulative feed efficiency of Experiment IV (males).

| Group | Rep. | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | week 7 |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 1.40 | 1.52 | 1.64 | 1.86 | 1.93 | 2.00 | 2.17 |
| 2 | 2 | 1.26 | 1.45 | 1.62 | 1.80 | 1.90 | 1.97 | 2.09 |
| 3 | 2 | 1.32 | 1.53 | 1.62 | 1.85 | 1.90 | 1.94 | 2.05 |
| 4 | 2 | 1.53 | 1.62 | 1.74 | 1.91 | 2.05 | 2.08 | 2.23 |
| 5 | 2 | 2.00 | 1.98 | 2.03 | 2.22 | 2.26 | 2.25 | 2.41 |
| 6 | 2 | 1.55 | 1.75 | 2.00 | 2.13 | 2.29 | 2.28 | 2.43 |
| 7 | 2 | 1.62 | 1.79 | 1.98 | 2.22 | 2.28 | 2.23 | 2.37 |
| 8 | 2 | 1.81 | 1.88 | 1.99 | 2.21 | 2.31 | 2.29 | 2.40 |
| 9 | 2 | 1.70 | 1.94 | 2.08 | 2.30 | 2.38 | 2.29 | 2.37 |
| 10 | 2 | 1.52 | 1.70 | 1.76 | 1.90 | 1.99 | 1.97 | 2.08 |
| 11 | 2 | 1.35 | 1.52 | 1.67 | 1.76 | 1.87 | 1.90 | 2.00 |
| 12 | 2 | 1.62 | 1.68 | 1.76 | 1.91 | 2.08 | 2.09 | 2.19 |

Average cumulative feed efficiency of Experiment IV (females).

| Group | Rep. | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | week 7 |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 1.33 | 1.50 | 1.63 | 1.89 | 2.11 | 2.10 | 2.22 |
| 2 | 2 | 1.28 | 1.46 | 1.62 | 1.86 | 2.03 | 2.07 | 2.22 |
| 3 | 2 | 1.59 | 1.67 | 1.77 | 1.99 | 2.16 | 2.19 | 2.33 |
| 4 | 2 | 1.56 | 1.67 | 1.76 | 1.98 | 2.10 | 2.19 | 2.37 |
| 5 | 2 | 1.67 | 1.89 | 2.00 | 2.20 | 2.33 | 2.34 | 2.45 |
| 6 | 2 | 1.59 | 1.75 | 1.90 | 2.09 | 2.33 | 2.33 | 2.46 |
| 7 | 2 | 1.71 | 1.93 | 2.06 | 2.31 | 2.39 | 2.38 | 2.48 |
| 8 | 2 | 1.70 | 1.81 | 1.99 | 2.20 | 2.41 | 2.15 | 2.47 |
| 9 | 2 | 1.59 | 1.70 | 2.01 | 2.28 | 2.37 | 2.34 | 2.59 |
| 10 | 2 | 1.62 | 1.72 | 1.81 | 2.07 | 2.07 | 2.09 | 2.23 |
| 11 | 2 | 1.44 | 1.57 | 1.74 | 1.92 | 2.21 | 2.07 | 2.23 |
| 12 | 2 | 1.50 | 1.60 | 1.68 | 1.84 | 2.02 | 2.04 | 2.14 |

TABLE (59).

Average weight (gr) of males of Experiment IV

| Group | Rep. | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | week 7 |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 86.50 | 183.50 | 332.00 | 473.00 | 651.50 | 906.00 | 1095.50 |
| 2 | 2 | 90.50 | 188.50 | 337.50 | 505.50 | 665.50 | 908.50 | 1137.50 |
| 3 | 2 | 87.00 | 183.00 | 333.00 | 474.00 | 638.50 | 879.50 | 1102.00 |
| 4 | 2 | 80.50 | 166.50 | 296.50 | 454.50 | 587.00 | 822.50 | 1013.00 |
| 5 | 2 | 76.00 | 147.50 | 257.50 | 383.50 | 530.50 | 751.50 | 923.00 |
| 6 | 2 | 78.00 | 157.50 | 293.00 | 454.00 | 583.50 | 816.00 | 1012.50 |
| 7 | 2 | 76.00 | 145.00 | 251.50 | 376.00 | 509.50 | 735.00 | 919.00 |
| 8 | 2 | 76.50 | 155.00 | 276.00 | 413.50 | 540.00 | 764.50 | 963.00 |
| 9 | 2 | 79.50 | 149.00 | 263.00 | 403.00 | 531.50 | 770.00 | 992.00 |
| 10 | 2 | 80.00 | 156.50 | 273.00 | 413.50 | 548.00 | 783.00 | 993.50 |
| 11 | 2 | 79.00 | 153.50 | 268.50 | 407.50 | 539.00 | 757.00 | 960.00 |
| 12 | 2 | 79.50 | 153.50 | 270.50 | 413.00 | 522.50 | 731.50 | 939.50 |

Average weight (gr) of females of Experiment IV

| Group | Rep. | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | week 7 |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 87.50 | 185.00 | 323.00 | 461.50 | 582.00 | 791.50 | 973.00 |
| 2 | 2 | 91.00 | 187.50 | 326.00 | 466.50 | 585.50 | 798.00 | 963.00 |
| 3 | 2 | 83.50 | 169.50 | 303.00 | 450.00 | 552.50 | 766.00 | 937.00 |
| 4 | 2 | 79.50 | 162.50 | 291.00 | 427.00 | 563.50 | 770.50 | 932.50 |
| 5 | 2 | 76.00 | 144.00 | 252.00 | 378.50 | 491.50 | 681.50 | 849.00 |
| 6 | 2 | 80.00 | 159.50 | 281.00 | 433.00 | 525.00 | 735.50 | 905.50 |
| 7 | 2 | 74.50 | 145.50 | 255.00 | 381.00 | 501.00 | 718.00 | 899.50 |
| 8 | 2 | 79.50 | 156.50 | 268.00 | 402.50 | 511.50 | 713.50 | 886.50 |
| 9 | 2 | 75.50 | 145.50 | 262.00 | 380.00 | 502.50 | 707.50 | 850.00 |
| 10 | 2 | 74.00 | 143.00 | 255.50 | 370.00 | 518.00 | 725.00 | 887.00 |
| 11 | 2 | 77.50 | 149.50 | 257.00 | 393.50 | 488.00 | 692.00 | 870.00 |
| 12 | 2 | 77.50 | 148.50 | 259.00 | 389.00 | 490.00 | 689.50 | 864.50 |

TABLE 60.

Chicks mortality record of Experiment IV.

| Sex | Gr. 1 | Gr. 2 | Gr. 3 | Gr. 4 | Gr. 5 | Gr. 6 | Gr. 7 | Gr. 8 | Gr. 9 | Gr. 10 | Gr. 11 | Gr. 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M | 3 | 1 | – | – | 2 | 2 | – | 2 | 1 | 2 | 1 | 3 |
| F | – | – | 3 | – | – | 2 | 2 | – | 3 | 3 | 2 | 1 |
| Total | 3 | 1 | 3 | – | 2 | 4 | 2 | 2 | 4 | 5 | 3 | 4 |

TABLE 61.

Average weight of chicks in Experiment IV.

| | | A.P. High Energy | P.P. | | | | | A.P. High Energy | P.P. | | A.P. High Energy | P.P. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | High Energy | | | High Energy | | | High Energy |
| | Sex | Gr. 1 | Gr. 4 | Gr. 5 | Gr. 6 | Gr. 9 | Gr. 10 | Gr. 2 | Gr. 7 | Gr. 11 | Gr. 3 | Gr. 8 | Gr. 12 |
| 7th week weight (gr) | M | 1095.5 | 1013 + | 923.0 ++ | 1012.5 + | 992.0 + | 993.5 + | 1137.5 | 919.0 ++ | 960.0 | 1102.0 | 963.0 + | 939.5 ++ |
| | F | 973.0 | 932.5 | 849.0 ++ | 905.5 ++ | 850.0 ++ | 887.0 ++ | 963.0 | 899.5 + | 870.0 ++ | 937.0 | 886.5 + | 864.5 ++ |

\+ $P < .05$
++ $P < .01$

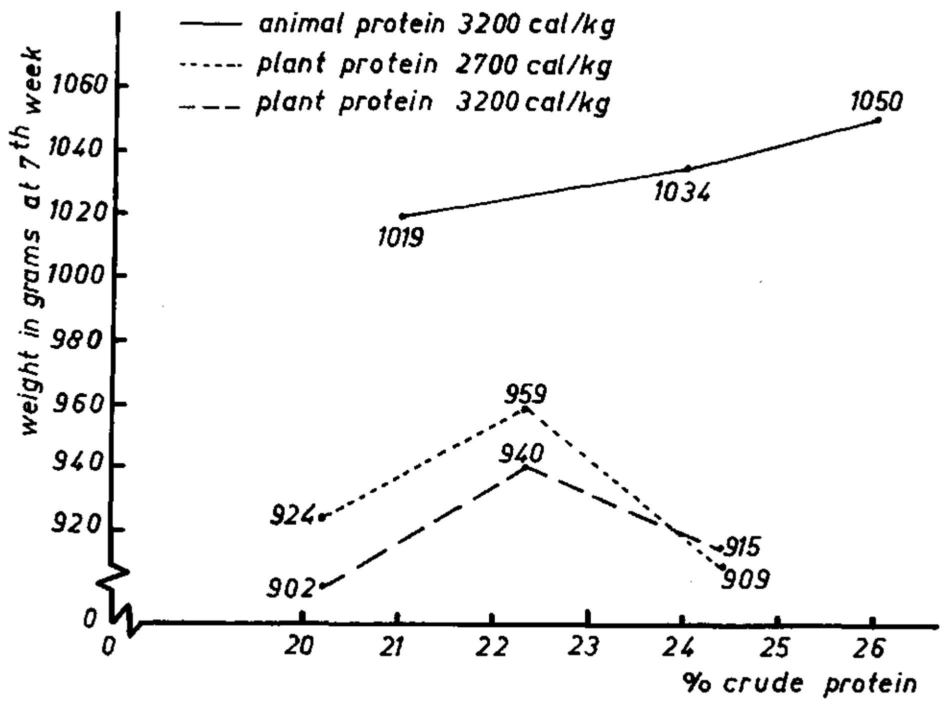


Fig. 6. Different crude protein levels and metabolizable energy and their effect on chicks' growth at 7 weeks. Exp. IV.

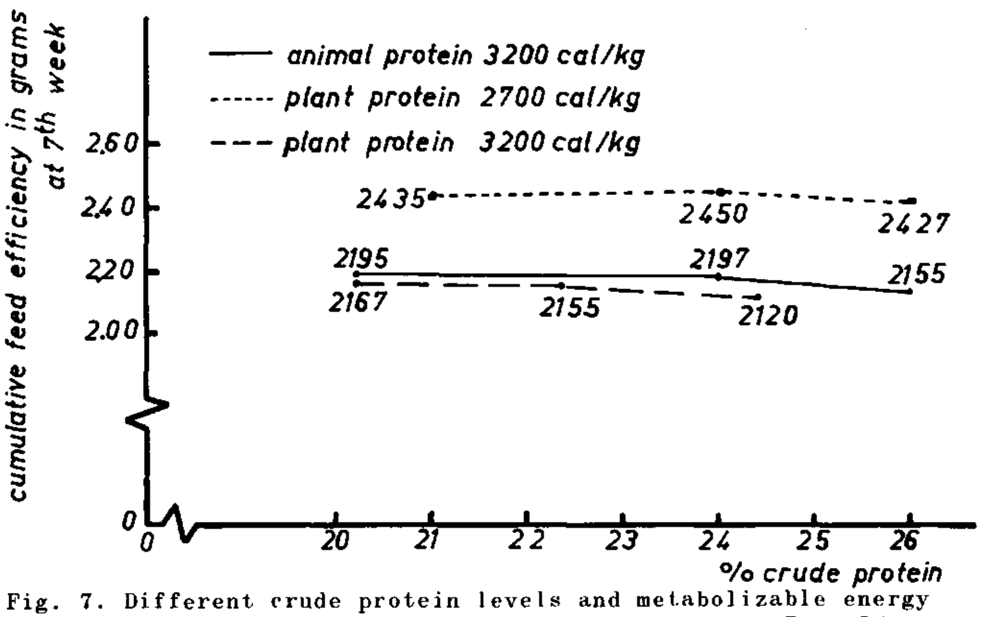


Fig. 7. Different crude protein levels and metabolizable energy and their effect on chicks' feed efficiency. Exp. IV.

TABLE 62.

Average cumulative feed efficiency of Experiment IV.

| | | A.P.(1) | P.P.(2) | | | | | A.P.(3) | P.P.(4) | | A.P.(5) | P.P.(6) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | High Energy | | | | | High Energy | High Energy | | High Energy | High Energy | | High Energy |
| | Sex | Gr. 1 | Gr. 4 | Gr. 5 | Gr. 6 | Gr. 9 | Gr. 10 | Gr. 2 | Gr. 7 | Gr. 11 | Gr. 3 | Gr. 8 | Gr. 12 |
| 7th week CM. Feed Eff. | M | 2.17 | 2.23 | ++ 2.42 | ++ 2.44 | ++ 2.38 | 2.08 | 2.09 | ++ 2.38 | 2.01 | 2.06 | ++ 2.40 | 2.19 |
| | F | 2.23 | ++ 2.38 | ++ 2.46 | ++ 2.47 | ++ 2.60 | 2.23 | 2.22 | ++ 2.48 | 2.24 | 2.34 | ++ 2.47 | ++ 2.15 |

\+ $P < .05$
++ $P < .01$

(1) A.P. = Animal protein group with $\pm$ 24% crude protein.
(2) P.P. = Plant protein group with $\pm$ 23% crude protein.
(3) A.P. = with $\pm$ 26% crude protein.
(4) P.P. = with $\pm$ 25% crude protein.
(5) A.P. = with $\pm$ 21% crude protein.
(6) P.P. = with $\pm$ 21% crude protein.

Experiment V.

In order to study the various aspects of the plant protein diets (sesame-corn-barley) in producing maximum growth, it was necessary to examine the requirement of some critical minerals such as zinc and sodium, since both are still under investigation.

Experimental evidence on the amount of salt and zinc required by broilers varies considerably. The various functions of salt and the unavailability of zinc in sesame meal may both have some bearing upon the recommended levels. On these considerations experiment V was conducted to determine the effect of additive zinc and sodium. Stock and management of this experiment were similar to previous ones. Eighty chicks were used, (20) in each group, (10) for each sex. The chicks were reared to four weeks of age only, and they were placed as is shown in table (63).

TABLE 63.
Random Selection Table

| Group | Male Lot No. | Female Lot No. |
|---|---|---|
| I | 1 | 9 |
| II | 4 | 6 |
| III | 7 | 3 |
| IV | 8 | 2 |

<u>Experimental Diets.</u>

Basal diets for this experiment were taken from experiment III. We added .03% $Zn\ SO_4.7H_2O$ to diet No.I, and .13% $Na\ Cl$ to diet No. II. Both of these quantities were added to diet III, while diet IV served as a control. Samples from all diets were analysed for Na availability and also the composition of the diets was calculated. Details of the experimental diets are given in the following tables.

TABLE 64.

Diets and Plan of Experiment V.

| Ingredient | Gr. 1 | Gr. 2 | Gr. 3 | Gr. 4 |
|---|---|---|---|---|
| Barley | 18 | 18 | 18 | 18 |
| Millet | 10 | 10 | 10 | 10 |
| Y. Corn | 30 | 30 | 30 | 30 |
| Sesame meal | 34 | 34 | 34 | 34 |
| Alfalfa meal | 5 | 5 | 5 | 5 |
| Vit. $AD_3$ Prep. | 0.13 | 0.13 | 0.13 | 0.13 |
| Vital | 1.50 | 1.50 | 1.50 | 1.50 |
| Minerals | 1.50 | 1.50 | 1.50 | 1.50 |
| Ca $HPO_4$ | 0.90 | 0.90 | 0.90 | 0.90 |
| Lysine Prep. | 0.50 | 0.50 | 0.50 | 0.50 |
| Vit. $B_{12}$ | + | + | + | + |
| Sesame oil | 4 | 4 | 4 | 4 |
| Choline | 0.0136 | 0.0136 | 0.0136 | 0.0136 |
| Zn $SO_4$ $7H_2O$ | 0.03 | – | 0.03 | – |
| Salt (Na Cl) | – | 0.13 | 0.13 | – |
| | 105.5736 | 105.6736 | 105.7036 | 105.3436 |

Results and discussion of Experiment V.

The effect of zinc sulphate and sodium chloride were tested in this experiment. The results of the 4th week average weight, feed efficiency and food consumption are presented in table (66).

They indicate that there was no significant improvement achieved in weight or efficiency. The result of additional Zn to diets 1 and 3 does not agree with the findings of Lease et al. (1960) when they used purified sesame rations. But it agrees with the findings of Supplee et al. (1958) when they reported that in a practical broiler (corn-soybean) ration addition of 48 mg of zinc per kg of the diet did not improve growth or feed conversion. To a certain extent the results confirm the findings of O'Dell et al. (1958) when they found that 35 p.p.m. of zinc was sufficient to promote normal chick growth and prevent keratosis in the presence of 1.6% calcium and 0.7% phosphorus. As the contents here were 1.2% calcium and 0.8% phosphorus, it seems that this fact is further corroborated. The addition of Na Cl to diets 2 and 3 did not improve weight or food consumption, and this is in accordance with N.R.C.(1960) requirements, where they give the figure of 0.15 per cent codium as a sufficient quantity in practical broiler rations. When both zinc sulphate and salt were added to diet 3, there was no noticeable improvement.

The statistical analysis showed no significant differences between treatments.

TABLE 65.

Zinc and Sodium calculated as added minerals in Exp. V.

| Minerals Content | Diet 1 | Diet 2 | Diet 3 | Control Diet 4 |
|---|---|---|---|---|
| (Na)% content<br>(Na)% added | .20<br>--- | .20<br>.05 | .20<br>.05 | .20<br>--- |
| Total | .20 | .25 | .25 | .20 |
| (Zinc) content<br>(Zinc) added<br>/ p.p.m. | 39.92<br>60 | 39.92<br>--- | 39.92<br>60 | 39.92<br>--- |
| Total | 99.92 | 39.92 | 99.92 | 39.92 |

TABLE 66.

Cummulative Food consumption (gr), cummultive feed efficiency and average wieght (gr) of the Males and Females of Experiment V.

| Group | Sex | Food consumption (gr) 7th week | Feed efficiency 7th week | Weight (gr) 7th week |
|---|---|---|---|---|
| 1 | M | 46.20 | 1.844 | 442.66 |
| | F | 42.80 | 1.943 | 413.75 |
| 2 | M | 46.26 | 1.846 | 429.00 |
| | F | 42.86 | 1.944 | 414.5 |
| 3 | M | 46.22 | 1.845 | 478.00 |
| | F | 42.82 | 1.944 | 412.22 |
| 4 | M | 46.24 | 1.847 | 429.50 |
| | F | 42.83 | 1.944 | 428.80 |

TABLE 67.

Mortality record of Experiment V.

| Sex | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| M | - | - | - | - |
| F | 2 | - | 1 | 1 |
| Total | 2 | - | 1 | 1 |

## Part. III

## Experiment VI.

### Biological determination of the limiting amino acid in the plant protein diet.

A biological assay was carried out in (Central Institute for Nutrition and Food Research T.N.O., Utrecht, The Netherlands) to observe the limiting amino acid of a feed mixture for chickens that contained no source of animal protein. The assay was based on determinations of the protein quality of the feed mixture after supplementation of essential amino acids in different combinations, using albino rats as experimental animals. Supplements containing the limiting amino acid might be expected to increase the nutritive value of the protein.

The same test series also served to compare the protein value of a chicken feed containing animal protein with the plant protein mixture, with and without supplements of amino acids.

### Experiment Procedure.

The samples to be studied were received from the "Instituut voor de Pluimveeteelt, Het Spelderholt", Beekbergen, in 50 kg amounts in jute bags.

They were analyzed for nitrogen content according to the Kjeldahl method with HgO as a catalyst. Two separate samples were analyzed, each one in duplicate.

| | percentage nitrogen | |
|---|---|---|
| | first determination | second determination |
| animal protein mixture | 3.69 | 3.65 |
| plant protein mixture | 3.36 | 3.32 |

The average N contents found correspond to a crude protein level (N x 6.25) of 22.94% in the animal protein mixture and of 20.88% in the plant protein mixture.

The samples to be studied were incorporated into experimental diets as the only source of protein in amounts supplying approximately 8% crude protein. The percentage composition of the rations is shown in table (68).

a. The net protein utilization, i.e. the percentage of the nitrogen consumed that was utilized for synthesis of body protein:

$$NPU = \frac{\text{body N exp. group - body N protein free group}}{\text{N intake exp. group-N intake protein free group}} \times 100$$

b. The true digestibility, i.e. the percentage of the nitrogen consumed that was not excreted in the faeces:

$$TD = \frac{\text{N consumed - (N faeces exp. group-endogenous N)}}{\text{N consumed}} \times 100$$

The endogenous nitrogen per 100 g food consumed was calculated from the amount of nitrogen excreted in the faeces by the rats fed on the protein-free ration.

c. The biological value, i.e. the percentage of the nitrogen absorbed that was utilized for synthesis of body protein. Since the NPU represents (by definition) the product of biological value and digestibility (divided by 100), the biological value can be calculated from the formula:

$$BV = \frac{NPU}{TD} \times 100$$

## RESULTS

The weight change of the experimental animals, the amounts of nitrogen consumed and the amounts of nitrogen present in the carcasses and in the faeces are shown in table (69) together with the values calculated from these data for NPU, TD and BV.

The results show that the utilization of the protein of the plant protein mixture is somewhat lower than that of the animal protein mixture. The digestibility of both samples is not distinctly different. Of the six rations containing the plant protein mixture supplemented with essential amino acids, two showed a somewhat higher NPU than the other four, the amino acid added to both of these rations was threonine. Obviously the addition of threonine to the plant protein mixture results in an improved utilization of the protein. This finding is supported by the greater weight gain of the animals fed rations supplemented with threonine. Therefore it is justified to conclude that threonine is the amino acid which limits the nutritive value of this plant protein ration for rats.

The NPU obtained upon supplementing the plant protein mixture with threonine was not distinctly lower than that of the mixture containing animal protein.

TABLE (69)

Results obtained with groups of 12 rats during an experimental period of 10 days.

| source of protein in ration | weight* | food eaten | N eaten | N in faeces | endogenous N in faeces | N in carcasses | nutritive value | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | NPU | TD | BV |
| | g | g | g | g | g | g | | | |
| none | 228 | 615 | 0.37 | 1.15 | 1.15 | 21.96 | - | - | - |
| animal protein mixture | 199 | 1269 | 16.62 | 4.06 | 2.37 | 33.98 | 74 | 90 | 82 |
| plant protein mixture | 139 | 1200 | 15.12 | 3.99 | 2.24 | 31.59 | 65 | 88 | 74 |
| p.p.mix.+hist.,lys.,isoleuc. | 170 | 1268 | 15.98 | - | - | 32.27 | 66 | - | - |
| p.p.mix.+meth.,threon.,phenylal. | 212 | 1320 | 16.63 | - | - | 33.80 | 73 | - | - |
| p.p.mix.+trypt.,val.,leuc. | 198 | 1352 | 17.04 | - | - | 32.85 | 65 | - | - |
| p.p.mix.+hist.,threon.,leuc. | 223 | 1357 | 17.10 | - | - | 33.98 | 72 | - | - |
| p.p.mix.+lys.,phenylal.,trypt. | 160 | 1228 | 15.47 | - | - | 32.18 | 68 | - | - |
| p.p.mix.+isoleuc.,meth.,val. | 185 | 1287 | 16.22 | - | - | 32.72 | 68 | - | - |

* Average Initial Body Weight for all rats were 77.3 grams.

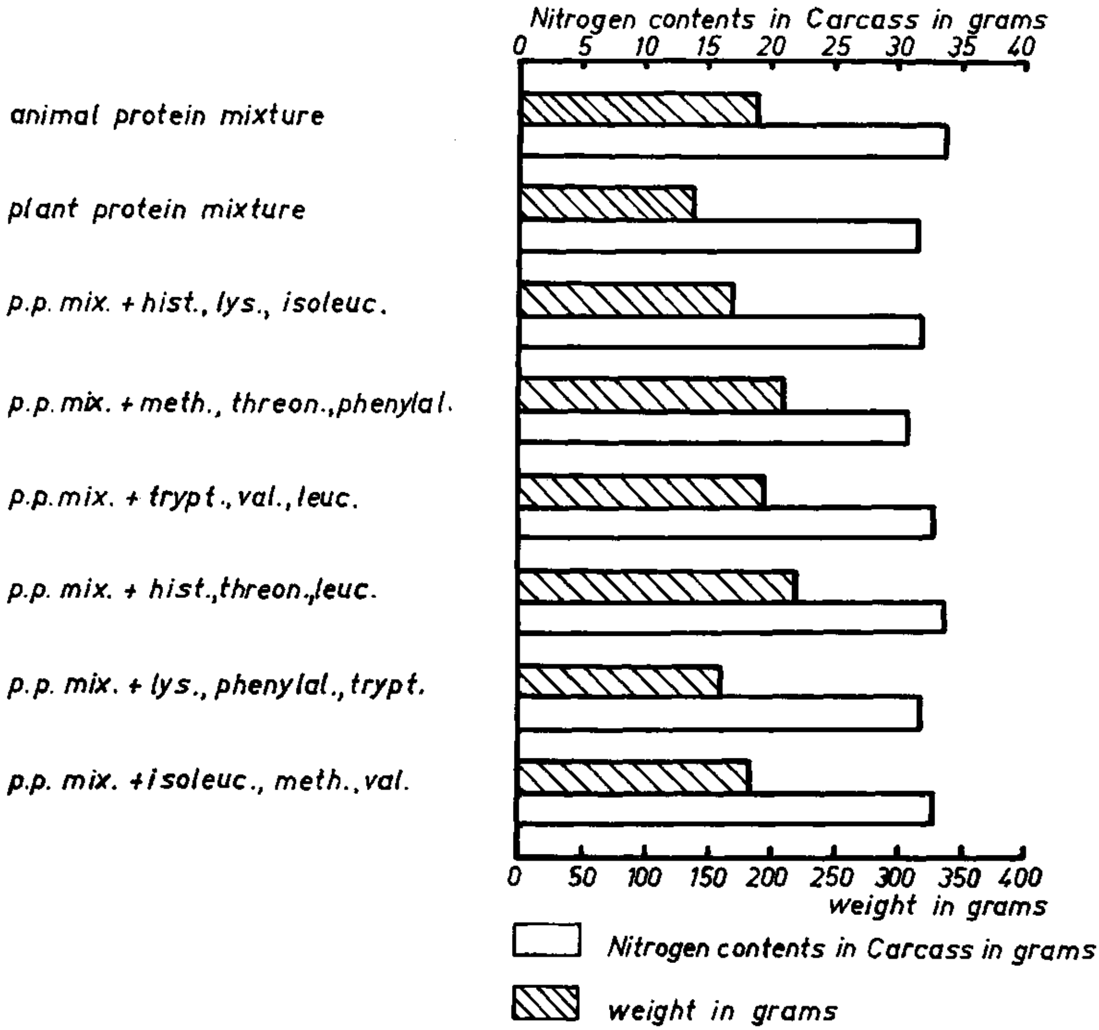


Fig. 8. Weight changes and nitrogen contents the carcasses of rats after 10 days. Exp. Vi.

## Experiments No. VII and VIII.

### Applying the biological determination results on practical broiler diets.

In the previous experiment with albino rats is was found that the amino acid threonine, limited the protein quality of a feed mixture containing only plant protein sources. According to the calculated amino acid contents the amount of threonine in this ration was enough to cover the requirements of chickens, whereas the amount of glycine was marginal. In order to find out whether threonine or glycine was limiting for chickens, two growth experiments were carried out in which the plant protein feed mixture was supplemented with both amino acids, either alone or in combination. For comparison a ration containing animal protein was included in the experiments.

In experiment No. 7 the rations were fed at a protein level of 22%. Moreover the plant protein feed mixture was relatively low in energy content*. Since these conditions might have prevented an effect of the amino acid supplements a second growth experiment No. 8 was carried out. In this experiment the protein level was reduced to 18% whereas the energy content was considerably higher**. Furthermore in the eighth experiment l-threonine was used as a supplement, whereas in the seventh experiment threonine was available only in the dl-form.

### Experiment Procedure.

The plant protein and the animal protein feed mixtures were supplied by "Instituut voor Pluimveeteelt, Het Spelderholt" Beekbergen. They were analyzed for nitrogen content by Kjeldahl analyses with HgO as a catalyst.

The feed mixtures used in the seventh chicken experiment were taken from the same batch as those used in the rat test. The nitrogen contents of the animal protein- and plant protein feed mixtures were found to be 3.67 and 3.34% respectively. The crude protein contents of both mixtures were equalized at a level of 22% by adding wheat starch to the animal protein feed mixture.

In the eighth experiment freshly prepared animal protein-

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* Animal protein mixture energy = ± 3200 Cal/kg
  Plant protein mixture energy = ± 2700 Cal/kg
**Animal and plant protein mixture energy =± 3200 Cal/kg

and plant protein feed mixtures were used, containing 3.22 and 3.65% N respectively. The crude protein contents of these mixtures were equalized and reduced to 18% by admixing calculated amounts of wheat starch. The protein content of the rations after adding the starch was checked by duplicate Kjeldahl analyses. The composition of the experimental rations and the nitrogen contents are presented in table (70).

TABLE (70).

Composition and nitrogen contents of experimental rations

experiment VII

| ration no. | composition | % nitrogen | % crude protein (Nx6.25) |
|---|---|---|---|
| 309 | animal prot.mixt. 90%+wheat starch 10% | 3.53 | 22.1 |
| 310 | plant prot. feed mixture | 3.55 | 22.2 |
| 311 | plant prot.+glycine 0.1% | - | - |
| 312 | plant prot.+glycine 0.1%+dl-threon. 0.2% | - | - |
| 313 | plant prot.+dl-threonine 0.1% | - | - |
| 314 | plant prot.+dl-threonine 0.2% | - | - |

experiment VIII

| ration no. | composition | % nitrogen | % crude protein (Nx6.25) |
|---|---|---|---|
| 336 | animal prot.mixt.89.4%+wheat starch 10.6% | 2.91 | 18.2 |
| 337 | plant prot-mixt.79.0%+wheat starch 21.0% | 2.91 | 18.2 |
| 338 | ration 337 + glycine 0.1% | - | - |
| 339 | ration 337+glycine 0.1%+l-threonine 0.1% | - | - |
| 340 | ration 337 + l-threonine 0.05% | - | - |
| 341 | ration 337 + L-threonine 0.1% | - | - |

Stock and Management.

One day old male chicks of a heavy cross breed ("Hybro") were obtained from a commercial hatchery. After individual weighing the heaviest and lightest animals were discarded. The remaining animals were wing-banded and equally divided over the experimental groups, each group consisting of 3 sub-groups of 8 animals. The chicks were housed in metal cages with wire-screen bottoms in a thermostatically controlled electrically heated battery. The animal room and the battery had been disinfected with formalin vapor before the experiment. The temperature of the battery was maintained at $\pm 34^{o}C$ during the first few days and was thereafter reduced gradually to $\pm 28^{o}C$ on the 12th (and final) day of the experimental period. Artificial light was provided continuously. The experimental rations and tap water were provided ad libitum.

After the 6th and the 12th day the animals were weighed individually and feed consumption was determined per sub group.

Results and Discussion.

The average body weights and feed conversion data are presented in table (71). The figures show that supplementation of the plant protein mixture with amino acids did not result in distinct differences in growth or feed conversion. In the seventh experiment the groups supplemented with glycine gained somewhat less in weight than the unsupplemented group. In the eighth experiment the group supplemented with 0.1% glycine showed the lowest average body weight and the highest feed consumption per g of weight gain. These observations indicate an unfavourable effect of glycine supplementation.

In contrast to the results of the seventh experiment the group receiving the supplement of glycine + threonine in the eighth experiment showed somewhat higher body weights and lower feed consumption per g of weight gain than the other groups fed plant protein feed mixtures. The difference in body weight between the group receiving glycine + threonine and that receiving only glycine was highly significant ($P < 0.001$).

The groups receiving extra threonine (without glycine) in the seventh experiment showed somewhat higher body weights than the non-supplemented group. These differences were, however, not significant. In the eighth experiment such an effect was not noticeable.

In conclusion it may be said that the plant protein feed mixture was not distinctly improved by supplements of glycine and threonine either alone or in combination. In both experiments the animal protein feed mixture showed better weight gain and more favourable feed conversion than the plant protein feed mixture.

TABLE (71).

Average weight and feed conversion

| ration no. | ration composition | average weight in g | | | feed conversion | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | day 0 | day 6 | day 12 | 0–6 days | 0–12 days | 0–12 days | | | |
| | | | | | | | subgr.A | subgr.B | subgr.C | A+B+C |
| | **seventh experiment, 22% crude protein** | | | | | | | | | |
| 309 | animal protein | 41.6 | 98.6±2.2* | 181.3±4.1 | 1.28 | 1.64 | 1.47 | 1.50 | 1.52 | 1.49 |
| 310 | plant protein | 41.6 | 86.3±2.4 | 160.1±5.3 | 1.43 | 1.72 | 1.55 | 1.64 | 1.65 | 1.61 |
| 311 | idem + glycine 0.1% | 41.6 | 84.9±2.1 | 157.0±2.9 | 1.43 | 1.75 | 1.62 | 1.62 | 1.65 | 1.63 |
| 312 | idem + glycine 0.1% + dl-threonine 0.2% | 41.6 | 86.2±2.9 | 156.2±5.6 | 1.44 | 1.76 | 1.55 | 1.67 | 1.68 | 1.64 |
| 313 | idem + dl. threonine 0.1% | 41.7 | 90.3±1.4 | 163.6±3.5 | 1.32 | 1.81 | 1.54 | 1.61 | 1.69 | 1.61 |
| 314 | idem + dl. threonine 0.2% | 41.6 | 90.1±1.5 | 164.1±2.7 | 1.42 | 1.75 | 1.65 | 1.56 | 1.66 | 1.62 |
| | **eighth experiment, 18% crude protein** | | | | | | | | | |
| 336 | animal protein | 38.5 | 79.5 | 151.0±3.9 | 1.50 | 1.79 | 1.66 | 1.69 | 1.69 | 1.68 |
| 337 | plant protein | 38.6 | 68.6 | 116.9±2.5 | 1.68 | 1.93 | 1.84 | 1.79 | 1.86 | 1.83 |
| 338 | idem + glycine 0.1% | 38.7 | 66.3 | 108.9±4.2 | 1.71 | 2.02 | 1.91 | 1.82 | 1.97 | 1.90 |
| 339 | idem + glycine 0.1% + l-threonine 0.1% | 38.5 | 71.5 | 122.2±3.1 | 1.60 | 1.90 | 1.84 | 1.76 | 1.75 | 1.78 |
| 340 | idem + l-threonine 0.5% | 38.5 | 68.1 | 115.8±3.8 | 1.69 | 1.93 | 1.86 | 1.77 | 1.93 | 1.84 |
| 341 | idem + l-threonine 0.1% | 38.5 | 69.7 | 117.5±3.9 | 1.60 | 1.95 | 1.76 | 1.75 | 1.94 | 1.81 |

x) standard error of the mean $\sqrt{\frac{\Sigma d^2}{n(n-1)}}$

PART. IV

CHAP. IV

## GENERAL DISCUSSION.

Since it was found that lysine is the first limiting factor involved in sesame meal, it was necessary to decide how much of the lysine should be added to get optimum growth in broiler rations.

It was also fruitful to study various other aspects of such an important plant protein e.g. the interrelationship between protein, energy, vitamins and minerals.

Four experiments were designed with various levels of lysine, methionine, energy and protein, the fifth experiment was conducted to check the adequacy of the sodium and zinc.

Experiment 6, 7 and 8 were assigned to study the biological value of the protein in the (sesame-corn-barley) diet. The average seven week body weights and average feed conversion calculated on a group basis were statistically analyzed according to Snedecor (1956); the "F" test was used as the basis for any statements of probability. When an experimental difference was found to be statistically significant by the "F" test, the "t" test was employed to test individual treatment differences within the experiment.

A discussion of the result was presented for each experiment, but it is useful to coordinate all the discussions together to give a general idea of the main points of this scientific investigation. From the results obtained from Expt. 1, 2, 3 and 4 we can state that 1.14% - 1.23% lysine of the (sesame-corn-barley) diet gave the best growth and this agrees with the findings of Almquist (1952), Klain (1957) as it coincides with Day's statement (1964) that the amino acid requirement cannot be stated very accurately since there is variation in protein quality.

When we consider the rate of growth since the cross breed we used in these experiments was a fast growing one, the statement of Edwards et al. (1956) fits perfectly. Higher lysine and methionine depressed growth and this fact agrees with the findings of Snetsinger and Scott (1961), and it leads to Dobson's and Anderson's statement (1961) when they reported that "balance" of essential amino acids is more important than has been previously considered. Additive vegetable oil did not improve the growth in any of the first four experiments, but the feed efficiency was increased, and the same conclusion has been reached by several workers, e.g. Henderson and Irwin (1940), Siedler and Schweigert (1953), Sunde (1954), Runnels (1954) and Donaldson et al. (1954). And it is important to refer to Sunde's statement (1954) in which he said that use of fat seemed to lead to deficiency of some nutrients.

Females in all the four experiments showed better response to lysine than males and this coincides with Scutze's finding (1958).

From the results of the grading of the carcass quality it was clear that high energy rations gave better quality and this agrees with March and Biely (1954).

The main point in experiment 3 was that replacing the quantity of barley entirely by corn did not give a better result even though the energy level increased, and this agrees with the finding of Arscott et al. (1958) when they concluded that barley can replace one half till three quarter of the ground corn. From the results of experiment 4 it was found that a uniform P/E ratio cannot readily be given irrespective of the energy level and protein quality.

This in agreement with the findings of Galet, Jovandet, Barabtou (1960, 1961) when they demonstrated that the optimum calorie/protein ratio varies with the nature of the dietary protein.

Testing the availability of zinc and the quantity of sodium in experiment V showed that approximately 20 ppm zinc and .15% sodium is enough to satisfy the chicks' need for growth. This agrees with the N.R.C. (1960) requirements and it also coincides with the findings of O'Dell et al. (1958) about the zinc requirements.

In the biological determination of the amino acids in experiment VI using Albino rats, it was found that the amino acid threonine limited the protein value. However, when this was tried on chicks in experiments VII and VIII, it was found no longer to be the case. The biological value of the plant protein diet of this experiment was found to be 90%, if it is compared to the animal protein value of the same experiment. Applying the Bartlett-test for homogenity of the variation of growth to experiments 1, 2, 3, 4 and 5 it was shown that treatments did not cause the difference in variance. To check the possible differences in the slope of the growth curve, the growth over the experimental period was divided into 3 components (level, linear and quadratic component) and a test of significance for the differences was made. The results show that in all the experiments, both sexes (except the females of experiment I) are concerned. The (negative) quadratic component of the growth curves was slightly significantly lower in the plant protein groups than in the animal protein groups. ($P < 0.01$).

This indicates clearly that though in most cases growth was a bit slower in the early growth stages in the plant protein groups.

This lag was partly recovered in later stages. This leads to the conclusion that for the later growth stages the plant protein mixture was adequate.

PART. V.

CHAP. V.

## THE ECONOMIC ASPECT.

Protein is an essential constituent of the chicks' diet, and it is generally the most expensive ingredient.

A scientific investigation was, therefore, necessary to find more ways of providing people of the developing countries with a ready source of animal protein at as low a cost as possible. One of the main purposes of the present study has been to formulate a plant protein diet for chicks which is less expensive than an animal protein diet but still of very high quality.

It was thought that this might be achieved by making use of the locally available plant protein feedstuffs, supplemented by essential amino acids, which can be produced much more cheaply than animal protein.

The following table which applies to the feed requirements in Iraq may serve to show the economic advantages of substituting the animal protein in the chick diet by a lysine preparation.

TABLE (72).

| Ingredients | Plant protein ration | Animal protein ration | Price 1 | Price |
|---|---|---|---|---|
| | kg. | kg. | I.D. | I.D. |
| Barley | 180. | 180. | 2 160 | 2 160 |
| Millet | 100. | 100. | 2 000 | 2 000 |
| Y. Corn | 300. | 300. | 8 100 | 8 100 |
| Sesame oil M.[2] | 340. | 147.[6] | 8 500 | 3 675 |
| Alfalfa Meal | 50. | 50. | - 750 | - 750 |
| Vital prep. | 15. | 15. | 2 115 | 2 115 |
| Mineral prep. | 15. | 15. | - 330 | - 330 |
| $A/D_3$ prep. | .120 | .120 | - 215 | - 215 |
| Vit. $B_{12}$ prep. | + | - | 3 250 | - - |
| Animal protein Supp.[3] | - | 200. | - - | 25 200 |
| Lysine prep.[4] | 7. | - | 7 000 | - - |
| Total | 1007.120 | 1007.120 | 34 420 | 44 545 |

[5]
I.D. Different in price approximately 10 I.D. per ton.

44.545
34.420
10.125

Table (72) shows clearly the economics of plant protein in mixed feeds for broilers production. Thus the use of the high quality feedstuff results in a gain of about 22.5%. Also if we calculate on the average feed efficiency basis we find that the plant protein groups produces 1000 kg of meat for 79.58 I.D. (2.312 x 34.42), while the animal protein groups give the same quantity for 96.53 I.D. (2.167 x 44.55). And this gives a difference of 16.95 I.D. per 1000 kg of chicken meat in favour of the plant protein groups. When this saving is viewed against the economic conditions in the Middle East nowadays, the soundness of the proposition becomes even more convincing.

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(1) Prices taken from Chamber of Commerce Bulletin Baghdad, Iraq (4th of April 1964).
Average current price per ton.
Barley = 12 I.D., Millet = 20 I.D., Y. Corn = 27 I.D., Sesame oil meal = 25 I.D., Dehydrated Alfalfa = 25 I.D. (world retail price)

(2) Sesame oil meal with average crude protein (42%).

(3) Animal protein percent (42%) crude protein supplied by Dutch firms to the Iraqi market. Price: Average: 12,500 I. D. per 100 kg.

(4) Lysine prep.65% active production of Staatsmijnen, Holland, average expected price is 8.00 Dutch Gulden = 800 Fils plus 25% profit for the agent = 10 Gulden = 1 Iraqi Dinar, per kilogram. (Personal contact with the Staatsmijnen of Holland, producer of the lysine preparation).

(5) IRAQI DINAR (I.D.) = 1000 Fils = 1 Pond Sterling = 10,08 Dutch Gulden.
10 percent added to the usual price due to 10% increasing level in the market since those supplements have been produced in Holland.

(6) Animal protein supplement gives average 8.40% protein to the diet so the sesame meal is reduced to give the level in the diet.

PART. VI.

CHAP. VI.

## CONCLUSION.

The purpose of this research was to formulate a diet of which the protein is entirely of vegetable origin (sesame meal-corn-barley-millet) because they are the most readily available ingredients in Iraq, and the Iraqi poultryman relies on them to feed his stock. Moreover the standard of living will not allow supplementation with animal protein, since it is rare and expensive.

In the first part of this publication it was necessary to make a review of the literature concerned. Due to the fact that protein vary so widely in amino acid content, it was necessary to study each ingredient and investigate chemically the specific amino acid amounts it contains; for this reason column chromatography and microbiological methods were used to measure the quantities of the amino acids in sesame meal - corn - barley etc. Following this step, five experiments were designed to study the various aspects of the plant protein diet (sesame - corn) etc. for broiler production. Three other experiments were conducted to study and determine the biological value and the limiting amino acid in such a diet.

Since we are concerned with meeting the amino acid requirement of the broilers, rather than meeting the requirement for total protein, it was assumed that adding the first limiting amino acid to the diet would give both optimum growth and performance. Thus in the first series of experiments 1, 2 and 3 we found that (1.14% to 1,23%) lysine in + 23% - + 22% crude protein is sufficient to meet the need of the fast growing chicks which have been used in these experiments.

The methionine content of the diet was always enough to meet the birds' need, because of the high methionine content of sesame, and this gives rise to the idea of using this excess.

Additive vegetable oil proved to be of no benefit, due to the unbalanced condition of other needed nutrients such as amino acids, minerals and vitamins. The only advantage is that high feed efficiency and better carcass quality can be obtained.

The mean growth rate reached was ranging between 93% to 97% or an approximate average of 95% of the animal protein groups.*

It was also found that the female** chicks respond to lysine better than the males. There is evidence to show from

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* Cotton seed meal gave maximum growth of 93& as found by Hobart, R. et al. (1963). Feedstuffs nov. '30.

** Females growth rate reached 99.5% in Exp. I "plant protein".

Conclusie.

Het doel van dit onderzoek was een rantsoen samen te stellen, waarvan het eiwit geheel van plantaardige oorsprong is, omdat sesam (schroot), gerst en millet gemakkelijk in Irak verkrijgbaar zijn en de Iraakse pluimveemesters deze voedermiddelen aan hun dieren toevertrouwen.

Daar komt nog bij dat de levensstandaard geen toevoeging van dierlijk eiwit veroorlooft, daar dit schaars en duur is.

In het eerste deel van deze publikatie is een overzicht van de desbetreffende literatuur gegeven.

Gezien het feit dat de eiwitten qua aminozurengehalte zo sterk variëren, was het noodzakelijk elk der gebruikte voedermiddelen aan een studie te onderwerpen en de gehalten aan de verschillende aminozuren chemisch na te gaan; er is gebruik gemaakt van de kolom chromatografie en microbiologische methodiek om de verschillende aminozuurgehaltes in sesamschroot, maïs, gerst, enz. te bepalen.
Hierna zijn 5 proeven opgesteld om de verschillende aspecten van een slachtkuikenrantsoen op basis van plantaardig eiwit (sesamschroot, maïs, enz.) te bestuderen. Vervolgens zijn nog 3 proeven genomen om in het hiervoor genoemde rantsoen de biologische waarde van het eiwit te bepalen en te onderzoeken welk aminozuur in het minimum was.

Daar het er om gaat de aminozuurbehoefte van de slachtkuikens te dekken en niet zozeer de totale eiwitbehoefte, is van de veronderstelling uitgegaan dat door toevoeging van het beperkende aminozuur de groei en opbrengst optimaal zouden worden.

Aldus hebben we in de eerste serie proeven (1, 2 en 3) gevonden dat 1.18% -1.29% lysine in ± 23 resp. ± 22% ruweiwit voldoende is om de behoefte der kuikens, die in deze proeven gebruikt zijn, te dekken.

Wegens het hoge gehalte aan methionine in sesam was het gehalte van het rantsoen aan dit aminozuur steeds voldoende om in de behoefte der dieren te voorzien. Het lijkt aangewezen van deze methionine overmaat een nuttig gebruik te maken. Een toevoeging van plantaardige vetten bleek geen gunstig effect te hebben ten gevolge van het feit dat andere essentiële nutriënten, zoals aminozuren, mineralen en vitaminen niet uitgebalanceerd waren. Het enige positieve effect is, dat een betere voederconversie en slachtkwaliteit kunnen worden verkregen.

De groeisnelheid bedroeg gemiddeld 95%, met uitersten van 93 - 97% van de groep met dierlijk eiwit. Tevens is gevonden dat de henkuikens beter op lysine reageren dan de haankuikens.

Uit proef VII blijkt dat het plantaardig eiwit een biologische waarde heeft van 90% van die van het dierlijk eiwit, maar door van toevoegingen gebruik te maken kunnen wij een beter groeipercentage bereiken.

Vanuit economisch standpunt bezien heeft dit onderzoek aangetoond, dat het in het Midden-Oosten beter is sesamschroot, maïs en gerst te gebruiken, waaraan lysine wordt toegevoegd dan dierlijke eiwitbronnen. Dit zal de economie in die landen zeer ten goede komen, omdat ze dergelijke grondstoffen zelf kunnen voortbrengen. Bovendien zal het de slachtkuikenmesters aanmoedigen meer vlees te produceren.


Samenvatting.

1. Een rantsoen op basis van sesamschroot, maïs en gerst, aangevuld met 0.50-0.78% lysine (1.18-1.29% in het totale rantsoen) bleek geschikt voor de productie van slachtkuikens, die in 7 weken een levend gewicht van ongeveer één kilogram bereiken.

2. De groei, behaald met sesamschroot, maïs, enz. was 96% t.o.v. de groei verkregen met de beste Nederlandse rantsoenen, op basis van dierlijk eiwit.

3. De gemiddelde voederconversie op een leeftijd van 7 weken was op een energierijk rantsoen met plantaardige eiwitten 2.149 en op een rantsoen met ± 2700 k cal omzetbare energie per kg 2.312.

4. Een toevoeging van sesamolie tot 10% van het rantsoen verhoogde het gewicht der kuikens niet, maar verbeterde wel de voederconversie en gaf een goede vleeskwaliteit te zien.

5. De henkuikens reageerden beter op lysine dan de haankuikens.

6. Plantaardige eiwitten variëren in voedingswaarde, daarom is het nauwkeuriger de waarden van het verteerbare eiwit te gebruiken dan die van het ruweiwit.

7. Daar sesam methioninerijk is, moet dit voor de officiële landbouwinstanties in de landen van het Midden-Oosten een aansporing zijn soja te verbouwen om de slachtkuikenindustrie te voorzien van een voedermiddel van goede kwaliteit. Soja is methioninearm en vormt een goede combinatie met sesam.

8. Wanneer er economisch gebruik gemaakt wordt van de resultaten van dit onderzoek, kunnen de kosten van een kwaliteitsvoeder met ongeveer 22.5% gedrukt worden (10 Files per kg). Gezien de omstandigheden in het Midden-Oosten, is het voor de mengvoederbereiding voordeliger gebruik te maken van een lysinepreparaat ter aanvulling van het rantsoen dan van dierlijk eiwit.

## الملخص

## البروتين النباتي المزود بالحوامض الامينية اللازمة واثرها في انتاج اللحم

### القسم الاول

آ ) في مقدمة هذه الرسالة نوقشت اهمية البروتين كمصدر اساسي لبناء الجسم الحي واثره الصحي ، واهمية زيادة انتاج اللحوم لمواجهة الطلبات المتزايدة المتأتية من تزايد السكان وارتفاع الدخل وكذلك انتشار الثقافة العامة النسبي في البلاد النامية حديثا ٠

ان انتاج اللحوم عن طريق تربية دجاج اللحم هو من اسرع الطرق العلمية الحديثة لذلك ، حيث اننا نتمكن من الحصول على الكميات اللازمة من اللحم ذي القيمة الغذائية العالية في مدة لا تتجاوز الشهرين ٠ لذا كان من الواجب ايجاد احسن السبل وايسرها لتوفير الغذاء المركز اللازم لهذه الدواجن لكي تنمو بأسرع ما يمكن وبأقل كمية غذائية ممكنة ، حيث ان المدة القصيرة التي يقضيها الدجاج في الحقل تُحتّم علينا ذلك ٠

ولكن من اهم مشاكل تربية هذا النوع من الدواجن في العالم عامة والبلدان النامية خاصة ، هو الحصول على البروتين الحيواني المركز باعتباره امرا ضروريا (ولازما كما كان يعتقد )لانتاج اللحم ٠ ان البروتين الحيواني المركز هو من اغلى اجزاء عليقة الدواجن علاوة على انه يصعب الحصول عليه ، وهو يشكل ٢٠ ٪ من مجموع العليقة تقريبا ٠ لذلك كان ضروريا دراسة الموضوع علميا وايجاد حل لهذه المشكلة٠ أي زيادة انتاج اللحم بدون استعمال البروتين الحيواني المركز ٠

ب ) في نهاية هذا القسم قدمت اهم المصادر التي تبحث حول الموضوع او قريبة منه ، ونوقشت هذه المصادر مناقشة ضافية لمعرفة ما يدور حول الموضوع من مناقشات واستنتاجات علمية ٠

### القسم الثاني

### القيمة الغذائية للمواد البروتينية ودراسة الحوامض الأمينية فيها

في هذا القسم درست المواد العلفية المتوفرة في منطقة الشرق الاوسط وخاصة في العراق، واختيرت خمس منها فقط ، لتمثل انتاج المنطقة الزراعي وهي : الشعير ، الذرة الصفراء، الدخن ، كسبة السمسم ، الجت ( البرسيم )٠ ومن هذه المواد شكلت علائق بسيطة مختلفة مع اضافة ما يلزم من فيتامينات ومعادن ضرورية رخيصة ، وذلك لدراسة امكانيتها الانتاجية ٠

لقد كان ضرورياً دراسة البروتين المكون لهذه المواد باعتبار ان البروتين ككل لا يعطي صورة واضحة لقيمته ٠ لذلك فقد حُلِلَ الى مواده الاساسية ( الحوامض الأمينية ) واستعملت لذلك طريقتان هما :

١) طريقة التحليل الكروموتغرافي

٢) طريقة التحليل الميكروبيولجي

ونتيجة لذلك فقد عُرفتْ بالضبط كمية الحوامض الأمينية الموجودة فعلاً في هذه المواد ، وعلى ضوء هذه المعلومات حُضِّرتْ العلائق الجديدة اللازمة ٠

## القسم الثالث

آ )  لقد اجريت خمس تجارب ، الاربع الأولى منها استمرت لمدة سبعة اسابيع لكل منها أما التجربة الخامسة فقد استمرت اربعة اسابيع فقط ، واستخدم لذلك (٩٦٠) فرخا لكل تجربة من التجارب الاربع الاولى و (٨٠) فرخا للتجربة الخامسة . في التجربتين الاولى والثانية حُضِّرتْ عدة علائق تحتوى كل منها على نسب مختلفة من الحوامض الأمينية وخاصة الحامض الأميني (اللايسين) باعتباره عاملاً مهماً في تحديد القيمة الغذائية لبروتين كسبة السمسم ، كما ظهر ذلك نتيجة للتحاليل السابقة . وكذلك جُرِّبَتْ نسب مختلفة من الحامض الاميني (الميثايونين) . كما اضيفت كميات مختلفة من الدهن النباتي (دهن السمسم) وذلك لفحص اثره والطاقة المتأتية منه واثرها في سرعة النمو واستهلاك العلف . أما التجربة الثالثة فقد خُصِّصَتْ لفحص القيمة الكمية لفيتامين (آ) و (الكولاين) وكذلك ملاحظة اثر الحامض الاميني (الميثايونين) على الاخير . اما التجربة الخامسة فقد خصصت لفحص زيادة كمية الملح ومعدن (الزنك) واثرهما في نمو الطيور .

ب )  في هذا القسم اجريت ثلاث تجارب لتثبيت القيمة (البيولجية) للبروتين النباتي ومقارنته بالبروتين الحيواني واثر الحوامض الأمينية الناقصة في توازن باقي الحوامض الأمينية ، وكانت التجربة تجرى على الفيران كمرحلة اختبارية ، ففي التجربة الاولى جرى فحص اثر اضافة احد عشر حامضاً امينياً . ونتيجة لذلك تبين ان الحامض الأميني (الثريونين) هو العامل المحدد لقيمة البروتين النباتي للفيران . ولذلك اجريت تجربتان اخرتان لتطبيق النتائج على الدواجن . هذا وقد اضيف الحامض الاميني (الكلايسين) باعتباره مهماً لنمو الأفراخ ولا يهم الفيران . ولكن النتائج في التجربتين كانت سلبية ، حيث لم يكن هناك اى زيادة تذكر في نمو الافراخ بعد زيادة الحامض الأميني (الثريونين) .

## القسم الرابع

في هذا القسم قدمت (مناقشة) عامة لكل النتائج لربط الحقائق مع بعضها البعض .

## القسم الخامس

لقد نوقشت الاهمية الاقتصادية للموضوع واثر استعمال البروتين النباتي كمصدر غذائي رئيسي بعد اضافة الحامض الأميني (اللايسين) المُحضَّر صناعياً . واجريت مقارنة للأسعار لجميع مواد العليقة بعد اضافة البروتين الحيواني وبدونه ، وبعد استعمال البروتين النباتي المجهز باللايسين .

## القسم السادس

واخيرا قدم استنتاج وملخص لجميع ما تقدم . كان اهم ما فيه هو ما يلي :

١) ان اضافة اللايسين الى علائق (تحتوى على البروتين النباتي فقط) بكمية تتراوح بين (٥ر٠٪ الى ٧٨ر٠٪) من العليقة ليكون (١٥ر١٪ — ٢٣ر١٪) من مجموع بروتين العليقة ، يعطي دجاجاً وزنه حوالي كيلوغرام واحد في مدة سبعة اسابيع فقط ، وان كمية العلف اللازم لانتاج هذه الكمية من اللحم هي (٤٩ر٢ الى ٢١٢ر٢) كيلوغرام من العلف تقريبا .

٢) ان طريقة البروتين النباتي تعطي ٩٥٪ نموا اذا ما قورنت بأحسن العلائق ذات البروتين الحيواني الكامل ، المستعملة في هولندة .

٣) ان السعر ينخفض بمقدار (١٠) فلوس للكيلوغرام الواحد ، او ما يعادل ٥ر٢٢٪ من قيمة العليقة الأصلية عند استعمال البروتين النباتي المزود باللايسين (المحضر تجاريا) اذا ما قورنت بسعر علائق البروتين الحيواني .

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