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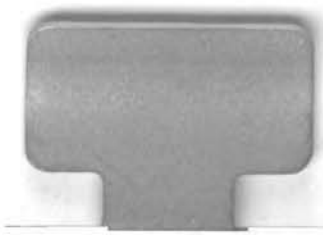

NUTRIENT REQUIREMENTS OF
DOMESTIC ANIMALS

NUMBER 1

Nutrient Requirements of Poultry

Revised 1960

A Report of the

N.R.C. Committee on Animal Nutrition
Agricultural Board

Prepared by the

Subcommittee on Poultry Nutrition

Publication 827

NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

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I. NUTRIENT REQUIREMENTS OF POULTRY

The Subcommittee on Poultry Nutrition of the National Academy of Sciences—National Research Council's Committee on Animal Nutrition was appointed in 1943 and charged with preparing nutrient-requirement standards for poultry. The first report of the subcommittee was published by the Academy Research Council in June, 1944. This has been revised at various times to take advantage of new findings of practical worth. The first revision of the tables of nutrient requirements was published in November 1946, a second in March 1950, and a third in January 1954.

Since 1954 new data have become available which necessitated revising the tables for a fourth time. In addition, valuable suggestions for improving the clarity, and thus enhancing the usefulness, of the tables have been received from persons working in the experiement stations and the commercial feed industry. The committee has attempted to incorporate these suggestions into the revised edition of the report.

The same general procedures were followed in making this revision as were used in compiling the original publication. The committee has attempted to evaluate the new data and at the same time keep in mind the data on which the original "Recommended Allowances" were based. Revised requirements listed in tables in this report are not to be considered as final. They will be further revised as new information of practical value on the quantitative requirements of poultry becomes available.

Nutrient requirements of chickens, turkeys, and ducks are given in Tables 1 to 4. Nutrient requirements of pheasants and quail are summarized for the first time in Tables 5 and 6.

Values given in these tables are based on the results of experimental work. Where several comparable experiments were available for consideration by the subcommittee, the values in the tables represent an approximate, but not necessarily an exact, average of the results.

Research workers conducting experimental work on the nutritive requirements of animals normally base their conclusions on the performance of groups of animals. Where performance is determined on the basis of gains in weight or feed efficiency, averages usually provide the basis for interpreting experimental work. Where deficiency symptoms are the criteria for determining nutrient adequacy or inadequacy, freedom from the deficiency syndrome of all animals in experimental groups is usually the basis of investigators' conclusions.

To make use of results of this character in preparing the tables of the *Nutrient Requirements of Poultry*, some calculations and interpolations were necessarily employed. Values, however, have not been increased by any intentionally added amounts, since the nature of the original findings indicate that they represent requiremets which are adequate and which permit the maintenance of normal health and productivity of animals.

In practical feed formulation, it is often desirable to include margins of safety to compensate for possible losses of vitamins during the feed processing, transportation, and storage, and for variations in feed composition and in environment. Individual feed manufacturers can best evaluate their own situations and determine margins most suitable to their specific conditions.

It has been customary for research workers in poultry nutrition to express nutrient requirements in terms of concentration of nutrient per unit weight of ration and this method has been followed in the present report. This convenient method is somewhat inaccurate because the nutrient intake of the animal is thereby subject to the absolute level of the feed consumption, which in turn is dependent mainly on the energy concentration in the ration.

Protein and amino acid requirements are particularly subject to this effect, because they represent more nearly fixed quantities required per day at a given stage of growth or production, rather than percentages of the ration. In its simplest terms, the protein requirement bears a fairly constant relation to the energy concentration of the ration, dependent on the stage of life. That this is true in principle has been shown experimentally in several laboratories. However, even this means of expressing protein requirement does not lead to fixed values, apparently because of protein-sparing effects of particular carbohydrate and fat combinations and other more obscure differences between rations.

Relative concentrations of protein and energy in the ration also have an important effect on the fat content of the body. In relative protein deficiency with ad libitum feeding, fat deposition is markedly increased. With higher protein levels relative to energy content, less fat is deposited. Increasing protein level above that required for maximum growth rate reduces fat deposition still further.

It is evident, therefore, that the protein requirement can be defined accurately only in relation to energy concentration, degree of fat deposition, and a limited range of nutrient combinations using those purified and practical feedstuffs which have been subjected to experimental study. For practical purposes in farm operations and feed manufacturing, sufficient work has been done with growing chicks to define, with reasonable accuracy, the minimum protein requirement for maximum growth rate in relation to energy level. Similar estimates can be made from more limited data for laying hens and growing turkeys.

Protein levels shown in Table 1 for chickens will meet the approximate minimum requirements for growth in rations containing 900 kilocalories of productive energy (Fraps) per pound, and for egg production in rations containing 920 kilo-

calories per pound. These energy levels are equivalent to approximately 1,300 kilocalories of metabolizable energy per pound.

Protein levels shown in Table 2 for turkeys will meet the approximate minimum requirements for early growth in a ration containing 800 kilocalories of productive energy per pound, and for later growth at an energy level of 850 kilocalories per pound. The equivalent metabolizable energy values would be approximately 1,140 and 1,200 kilocalories per pound.

When energy concentrations are used which are materially different from those on which the tables are based, proportionate changes in protein level will be necessary to maintain protein adequacy. The estimates apply primarily to rations based on natural feedstuffs customarily used in practical rations.

Requirements for vitamin A have been expressed in U.S.P. units of vitamin A activity per pound of feed. This is possible because in the chick as in the rat, 0.6 micrograms of beta-carotene appears to be equivalent to one U.S.P. unit of vitamin A, except when the carotene intake provides vitamin A activity greatly in excess of the requirement.

Requirements for vitamin D have been expressed in International Chick Units per pound of feed inasmuch as chickens and birds generally use vitamin D_3 from fish oils and irradiated animal sterol effectively but do not use vitamin D_2 from irradiated ergosterol as efficiently as do rates and other mammals. Vitamin D produced by irradiation of 7-dehydro-cholesterol may be more efficiently utilized by growing chicks and turkey poults than vitamin D from fish oils. This difference in the efficacy of the vitamin D from fish oils and irradiated animal sterols is particularly apparent when the ration is low in inorganic phosphorus. Turkeys are especially sensitive to the type of phosphorus present in the diet in relation to the type of vitamin D used. These factors have been considered in arriving at the recommended requirements for vitamin D, and the requirements listed are based on suggested minimum quantities of inorganic phosphorus. With the suggested amount of inorganic phosphorus, no difference in efficacy of vitamin D from fish oils and irradiated animal sterols should be observed in practice. The vitamin D requirement for breeding turkeys are the same as that for growing poults because it is believed requirements for breeding turkeys are no less than for growing turkeys.

Requirements for all other vitamins and for the trace elements have been expressed in milligrams per pound, while the requirements for protein, calcium, phosporus, potassium, and sodium have been given in percentage.

Betaine can be used interchangeably with choline in meeting the needs of the chicken for methylating agents but will not replace choline for its other functions, such as perosis prevention. Betaine appears to be widely distributed among practical feedstuffs and thus may be important in sparing choline. Likewise, vitamin B_{12} has been shown to reduce the requirement of the chick for choline. The figure for choline requirement given in Table 1 is intended to be applicable to conditions that would be encountered in practice.

The type of dietary carbohydrate has been shown to influence requirements of some of the water-soluble vitamins. Therefore, in establishing the requirements of these vitamins, greater weight was given to the results of experiments in which starch rather than one of the sugars was the principal dietary carbohydrate. This consideration was especially important in the case of folacin.

Requirements for vitamin E vary so much, depending on the nature of the diet, that it seemed inadvisable to include figures in Table 1. Chicks have been reared on purified diets very low in fat without any detectable vitamin E. Vitamin E requirement is increased by high levels of unsaturated fats and decreased by the presence of antioxidants. A part, but not all, of the biological function of vitamin E can be fulfilled by selenium.

Need for a minimum level of inorganic phosphorous is indicated in the footnotes to Tables 1 and 2. This need is based on the generally greater availability of inorganic phosphorous than of phytin phosphorus. Inorganic phosphorus supplements differ among themselevs in availability, and it is important that the minimum level of inorganic phosphorus be provided in readily available form.

Experimental data have become available during the past several years which make it possible to give a more complete table of requirements for the essential amino acids. These requirements are given in Table 3.

This revision, like previous ones, gives tentative requirements for certain vitamins and minerals. In this revision, however, tentative values are listed in the same tables as the better established values and are distinguished by italic type. In a sense, all the values are tentative inasmuch as they are subject to revision as new data become available. The values marked "tentative" are those based on a limited number of observations as in the case of iron and copper, or on conflicting reports as in the case of vitamin B_{12}. Much of the disagreement on vitamin B_{12} requirements is undoubtedly the result of the chicken's ability to store this vitamin and transmit it from dam to offspring. Mutual sparing effects and other inter-relationships between vitamin B_{12} and other nutrients have probably also contributed to the disagreement. High levels of dietary fat have been reported to increase the chicks vitamin B_{12} requirement ten-fold. The subcommittee believes that the quantities of vitamin B_{12} given in the table should be furnished by animal protein supplements or vitamin B_{12} supplements. Although there are published reports assigning a low vitamin B_{12} potency to grains, alfalfa meal, and other products of plant origin, it is believed that these materials make no measurable contribution to the chicken's vitamin B_{12} requirement.

It is impossible, of course to give quantitative requirements for unknown dietary factors. Nevertheless, account must be taken of their existence. A diet that supplies the specified levels of the known nutrients but does not supply the unknowns is inadequate for best performance. There is evidence for four distinct growth factors in dried whey, marine and packing house by-products, distillers solubles, and certain green forages. Whether these materials differ from each other

in the nature of their organic factors is not known. There is evidence for at least one unknown hatchability factor in fish solubles and green forage.

In recent years, several antibiotics have assumed an important place in poultry feeds because they increase growth rate and efficiency of feed utilization. They are not nutrients and it would not be appropriate to include them among the nutrient requirements. They appear to exert their effect upon the growth of the chicken by bringing about a change in the bacterial population of the digestive tract. Depending on the antibiotic used, 1 to 5 milligrams per pound of feed are needed to produce the desired effect.

II. SYMPTOMS OF NUTRITIONAL DEFICIENCIES IN CHICKENS AND TURKEYS

The more common gross pathological symptoms seen in poultry maintained on diets deficient in the various nutritional factors are herein described and illustrated. One shortcoming of such a description is that the symptoms are observed, for the most part, in poultry fed rations severely deficient in some specific factor. Under these conditions only the acute symptoms develop, which, in most cases, are quite characteristic for each nutritional factor, thus making a diagnosis relatively easy. On the other hand, the gross symptoms observed in chronic deficiency of any one of several factors may be similar (perhaps only retarded growth, ruffled plumage, etc.), thus making an accurate diagnosis difficult if not impossible. The chronic deficiency may be more serious in the long run than the acute, since diagnosis and treatment of the latter condition may be readily obtained while the chronic deficiency continues to exist because of failure to diagnose it.

Vitamin A

On a severely deficient diet the symptoms of vitamin A deficiency in chicks begin to appear in approximately three weeks. Growth is markedly retarded and the chicks show general weakness, emaciation, staggering gait, and ruffled plumage, (Fig. 1). Resistance to infection is reduced and mortality is increased. The secretions of the intestinal mucous glands, the tear glands, and the salivary glands fail. An opaque appearance caused by keratinization of the third eyelid may be observed. Infection may occur, resulting in the production of a viscous fluid which may cause the eyelids to stick together.

Pathological lesions observed on autopsy are confined largely to the mucous membranes of the mouth, pharynx, esophagus, and respiratory and urinry systems.

Creamy white pustules often are found on the roof of the mouth and along the esophagus, sometimes extending into the crop (Fig. 2). Urates accumulate in the ureters and in the kidney tubules, causing these organs to become enlarged and creamy white in color (Fig. 3). This urate accumulation is detected easily on gross examination because of its whitish appearance.

In mature fowl, the symptoms noted for chicks may develop much more slowly, but the eye disorder often becomes more acute. A cheesy exudate from the eyes often is observed, as well as a sticky discharge from the nostrils. Egg production and hatchability are markedly reduced.

Symptoms of vitamin A deficiency in turkey poults are, in general, similar to those described for chicks but are usually much more acute.

Vitamin D

A lack of vitamin D in the absence of direct sunlight results in the nutritional deficiency termed rickets. The chicks are retarded in growth, show a disinclination to walk or walk with a lame, stiff-legged gait, and have an ungainly manner of balancing the body (Fig. 4). The chicks appear generally unthrifty. In this disorder an upset occurs in the mechanism involving the absorption and retention of calcium and phosphorus, as a result of which these minerals are not deposited in normal amounts in the bony structure of the body. Abnormal bone development may be detected most readily in the legs and at the junction of the ribs on the sides of the breast. The spinal column may be curved, and the sternum usually shows acute lateral bending or depression. Enlargement of the hock joints and beading of the rib ends becomes apparent. The beak is soft and rubbery and may be easily bent.

Inasmuch as vitamin D is concerned in calcium and phosphorus absorption and retention, a deficiency of either of these mineral elements may cause symptoms somewhat similar to those described for vitamin D deficiency. Grossly the symptoms may not be distinguishable one from another, except that that the legs appear normal in phosphorus deficiency. Under practical conditions, however, vitamin D is the factor usually lacking, because a deficiency of calcium or phosphorus hardly ever becomes so acute as to bring about these symptoms.

In mature laying birds, the first symptom of a vitamin D deficiency is the laying of thin-shelled eggs, followed very shortly by decreased egg production. The breast bone becomes soft and rubbery, and the bones of the legs and wings become fragile and easily broken. Birds may temporarily lose the use of their legs and squat in a "penquin-like" manner, a symptom which sometimes has been called "egg-paralysis." Hatchability is markedly reduced.

Symptoms of vitamin D deficiency in turkeys are very similar to those described for chickens.

Vitamin E

A lack of vitamin E in the ration of growing chicks results in the condition known as nutritional encephalomalacia. Chicks with this deficiency disease suddenly

become prostrated, lying with legs outstretched and toes flexed (Fig. 5). The head is retracted and often twisted laterally. Before the chicken becomes completely prostrated, its gait and other movements are often incoordinate. Upon autopsy, lesions are found in the cerebellum and sometimes in the cerebrum. In many chicks, necrotic reddish or brownish areas on the surface of the cerebellum can be seen by inspection. Under some conditions vitamin E deficiency results in subcutaneous edema and edema of the heart and pericadium.

In mature fowls, a prolonged vitamin E deficiency results in sterility in the male and reproductive failure in the female. Degenerative changes in the testes of the male may occur, resulting in permanent sterility. In females, egg production apparently is not affected by a vitamin E deficiency, while hatchability is reduced markedly. During incubation the rates of growth and differentiation are slow, and many embryos die during the first two days of development because of a circulatory failure. A definite critical period in the development of the embryo occurs about the fourth day.

Vitamin E deficiency in poults is known as nutritional myopathy. This condition is characterized by lesions in the muscular wall of the gizzard. These lesions appear as circumscribed gray areas, which often are of firmer texture than normal muscle and in some instances suggest presence of scar tissue.

Vitamin K

A lack of vitamin K greatly delays the clotting time of the blood, and chicks fed a deficient ration may bleed to death from any injury or bruise which causes rupture of blood vessels. Hemorrhages may occur subcutaneously, intramuscularly, intraperitoneally, or in any part of the chick's body (Fig. 6). The hemorrhages vary in size and appear to be the only symptom of the deficiency.

Mature birds do not seem to be subject to the acute vitamin K deficiency, indicating that they may synthesize the vitamin to some extent. It has been shown, however, that laying birds fed a vitamin K-low diet produce eggs low in vitamin K. When these eggs are incubated, chicks are hatched which have very low reserves of vitamin K with an accompanying prolonged blood-clotting time. As a consequence the chicks may bleed to death from an injury such as may result from wing-banding.

Thiamine

Day-old chicks when placed on a thiamine-low ration develop polyneuritis within 9 to 12 days. In the acute stage of polyneuritis the head may be drawn over the back (Fig. 9). Diets containing suboptimal amounts of thiamine, when fed to chicks, lead to loss of appetite, emaciation, impairment of digestion, general weakness, and frequently to convulsions.

Symptoms of thiamine deficiency in mature birds and turkeys are similar to those described for chicks.

Riboflavin

A lack of riboflavin in the diet of young chicks results in diarrhea, retarded growth, and paralysis of the legs, sometimes called curled toe paralysis. It involves the legs and feet and occurs in two stages, a preliminary stage which is curable and an acute stage which is incurable. Nutritional paralysis is characterized by the sudden appearance of chicks walking on their hocks, with toes curling inward; otherwise, the chicks appear to be in excellent health (Fig. 8). Chicks receiving rations only partly deficient in riboflavin often recover spontaneously. In severe cases of the paralysis the brachial and sciatic nerves show very marked hypertrophy and softening which are usually discernible by inspection. The symptoms are quite pronounced and most often observed in the sciatic nerve. The nerves occasionally reach a diameter of four to five times the normal size.

Riboflavin deficiency in breeding birds results in poor hatchability. The requirement for hatchability is considerably higher than that for egg production and maintenance of health. The embryos that fail to hatch as a result of a riboflavin deficiency are dwarfed and show a high incidence of edema, degeneration of the Wolffian bodies, and a characteristically defective down development, termed "clubbed" down. On a ration moderately deficient in riboflavin, many embryos die during the second week of incubation. The mortality reaches a peak about the eleventh day of development.

Pantothenic acid

Pantothenic acid deficiency in young chicks results in retarded growth, and feather development is extremely ragged. Within 12 to 14 days the eyelids become granular and stick together as a result of a viscous exudate. Crusty scabs appear at the corners of the mouth and around the vent (Fig. 11). Dermatitis of the feet sometimes is observed in pantothenic acid deficiency, though the lesions are seldom as severe as those brought about by a biotin deficiency. Liver damage and changes in the spinal cord may be seen on post-mortem examination.

Lesions in adult fowl similar to those of growing chicks have not been observed although a deficiency of pantothenic acid results in lowered hatchability.

Niacin

A deficiency of niacin in the diet of chicks results in "black tongue," a condition characterized by inflammation of the tongue and mouth cavity. Beginning at about two weeks of age, the entire mouth cavity, as well as the upper part of the esophagus becomes distinctly inflamed with a deep red color in contrast to the normal pink of healthy chicks. Growth is retarded and feed consumption reduced (Fig. 7). Poor feather development and occasionally scaly dermatitis of the feet and skin are also observed.

Turkey poults fed a diet deficient in niacin develop a hock disorder similar to perosis. The same condition can be produced somewhat less readily in chicks.

Vitamin B_6

Chicks fed a vitamin B_6-deficient diet show a small initial gain, then cease to grow or grow very slowly. Some chicks show abnormal excitability and, somewhat later, jerky convulsive movements. Chicks may suddenly run about aimlessly, often flopping their wings and keeping their heads down. Convulsions may occur and during these convulsions the chick may rest on its breast, raise its feet off the floor, and flop its wings. Chicks may fall on their sides or roll over on their backs and rapidly paddle their feet. The head often jerks up and down or retracts as in polyneuritis and sometimes moves convulsively in an up-and-down movement with the neck distended or twisted. Complete exhaustion follows such convulsions and is frequently fatal.

Vitamin B_6 deficiency in mature birds is characterized by loss of appetite, followed by rapid loss of weight and death. Egg production and hatchability are markedly reduced.

Choline

Retarded growth and perosis indicates lack of choline in the diet of young chickens and turkeys (See Manganese). Choline deficiency in mature birds has been reported to result in increased mortality and lowered egg production, with an increased abortion of egg yolks from the ovaries. More recently, however, experiments reported from two laboratories have indicated that choline may be synthesized by the laying hen in quantities adequate for egg production.

Biotin

Biotin deficiency in chicks results in a dermatitis somewhat similar to that observed in pantothenic acid deficiency. Lesions first appear in about three weeks, although considerable variation in time of appearance has been noted. The bottoms of the feet become rough and calloused and hemorrhagic cracks appear (Fig. 10). The toes my become necrotic and slough off, but the top of the foot and the leg usually show only a dry scaliness. Mandibular lesions which first appear in the corners of the mouth spread to include the area around the beak. Eyelids eventually become swollen and stick together. In contradistinction to these symptoms, the lesions in pantothenic acid deficiency are first evident in the corners of the mouth and eyes, and only in extreme cases do the lesions of the feet become so severe.

Biotin has been reported to be one factor necessary for the prevention of perosis in chicks and turkeys. Turkey poults exhibit symptoms very similar to those described for chicks when fed a biotin-deficient ration.

When feeding mature fowl a biotin-deficient ration causes reduced hatchability while egg production is not adversely affected. This indicates that the requirement of biotin for producing hatching eggs is much higher than that necessary for maintaining good health and egg production. In hens, dermatitis similar to that of chicks fed biotin-deficient rations has not been observed.

Folacin

Folacin deficiency in young chicks results in retarded growth, poor feathering, and, in colored chicks, feather depigmentation. These symptoms are accompanied by the development of an anemia which is characterized by a reduction in number of red blood cells and hemoglobin. The red cell size and the hemoglobin content of the cells, however, are increased. The red blood cells are also abnormally shaped and less fragile than normal.

Vitamin B_{12}

Vitamin B_{12} has been shown to be essential for chick growth. No specific symptoms have been described which can be attributed to a vitamin B_{12} deficiency. However, growth and hatchability are markedly reduced. There is a marked carry-over of the vitamin from the breeding hen to the young chick and mortality may be high among chicks deficient in the factor at hatching time.

Calcium and Phosphorus

Calcium, phosphorus, and vitamin D are closely interrelated in bone formation. A deficiency of any one of these results in rickets, although the blood picture may vary, depending on the factor that is lacking. Retarded growth and increased mortality are also symptoms of calcium and phosphorus deficiency.

Manganese

A manganese deficiency in the diet of growing chicks and poults results in perosis or slipped tendon (Fig. 12). As has been mentioned, perosis may also be caused by a deficiency of choline or biotin.

Perosis is a malformation of the bones of chicks. The symptoms usually observed are swelling and flattening of the hock joint with subsequent slipping of the Achilles tendon from its condyles. The tibia and the tarsometatarsus may exhibit bending near the hock joint, and lateral rotation. One or both legs may be affected. A shortening and thickening of the long bones of the wings and legs is also observed. The disorder, insofar as manganese is concerned, is aggravated by excessive quantities of calcium and phosphorus in the ration.

In laying and breeding birds, a manganese deficiency results in lowered egg production, egg shell strength, and hatchability. Numerous embryos that die as a result of manganese deficiency exhibit chondrodystrophy, a condition characterized by a parrot-like beak, wiry down, and shortening of the long bones. This condition is not, however, specific for manganese deficiency.

Magnesium

When fed a diet deficient in magnesium, chicks grow slowly for about one week, then cease growing and become lethargic. When disturbed they exhibit symp-

toms similar to those of other species fed diets deficient in magnesium. Chicks show a brief convulsion, then go into a comatose state which sometimes terminates fatally but usually ceases in a few minutes.

Iodine

Iodine deficiency in the chick's diet results in goiter. The thyroid gland increases to many times the normal size. Histological examinations of the enlarged thyroid glands show an absence of colloid and a hyperplasia of the living cells of the follicle.

Iron and Copper

Animia is the result of an iron and copper deficiency in the chick's diet. This type of anemia is characterized by a reduction in the hemoglobin content of the blood and a reduction in the size of the red blood cell. A reduction in number of red cells, however, does not usually occur.

Zinc

In zinc deficiency, growth is retarded and feather development is extremely poor. The long bones of the legs and wings become shortened and thickened and the hocks enlarged. Slipped tendon, however, does not develop as in manganese deficiency but bone ash is at times slightly reduced. Occasionally the skin on the foot pads becomes dry and thickened and fissures in the epidermis which penetrate into the subcutaneous tissue develop. The principal lesion is that of hyperkeratosis.

III. COMPOSITION OF FEED INGREDIENTS AND FEED REQUIRED FOR PRODUCTION

Previous revisions of this report contained tables of composition of ingredients commonly used in poultry feeding. These were included to facilitate the formulation of feeds that would satisfy the nutrient requirements. Such tables were omitted from this revision in the interests of economy. The reader is referred to Publication 659 of the Academy—Research Council, "Joint United States-Canadian Tables of Feed Composition."

Feed Required for Production of Meat and Eggs

Data showing the approximate quantities of feed required for the production of eggs are presented in Table 6. Data on the quantities of feed required and the

time required to attain certain weights in chicks and turkeys are given in Tables 7 and 8. The figures given are typical values for the breed represented. Considerable variation from the figures given may result because of strain variation, the amount of feed wasted, and quality of feed. They are presented to serve as a guide in estimating the amount of feed required for a given purpose.

IV. DAILY REQUIREMENTS

The daily nutrient requirements for light and heavy breeds of chickens, presented in Tables 9 and 10, were computed from values given in Tables 1 and 7 of this report. It is hoped that these figures will be of value in studies on comparative nutrition. By expressing the requirements for all species and types of farm animals on a uniform basis, any basic relationships in their nutritive requirements will be made apparent.

V. SUMMARY

An attempt has been made to bring together in a condensed report information regarding the nutritional requirements and the symptoms of nutritional deficiencies of poultry. It is believed that the report will be useful to all who are concerned with the formulation and manufacture of poultry rations and with the teaching of poultry nutrition. County agricultural agents, high school teachers, and feedmen, who do not have library facilities or the time to study the original reports in the literature will also find it useful in answering questions regarding nutritional problems of poultry.

The dietary requirements should serve as a yardstick in determining the adequacy of any particular ration, at least for the better known nutritionl factors. It should be emphasized, however, that the dietary requirements listed do not represent all of the nutritional factors required by poultry for optimum results. Other factors remain to be isolated and identified, and the requirements of poultry for these factors and their distribution in feedstuffs must then be determined.

A brief description of the more common gross pathological symptoms that are observed in poultry receiving nutritionally incomplete diets has been included to aid in recognizing the nutritional deficiency diseases. Very probably some of these will never appear under practical conditions. On the other hand, deficiencies in vitamin A, vitamin D, riboflavin, and manganese may occasionally appear among

growing chicks and breeding hens. It is hoped that the description of the symptoms along with the photographs of actual cases will aid in early recognition and treatment of diseases resulting from nutritional deficiency.

REFERENCES

Amino Acids

Adkins, J. S., E. C. Miller, H. R. Bird, C. A. Elvehjem, and M. L. Sunde. An estimate of the threonine requirement of the laying hen. Poultry Sci. *37*:1362-1367, 1958.

Almquist, H. J. Evaluation of amino acid requirements by observations on the chick. J. Nutrition *34*:543-563, 1947.

Almquist, H. J. Amino acid requirements of chickens and turkeys. A review. Poultry Sci. *31*:966-981, 1952.

Anderson, J. O., and C. I. Draper. Protein supplements for laying rations high in wheat. Poultry Sci. *35*:562-566, 1956.

Edwards, H. M., Jr., L. C. Norris, and G. F. Heuser. Studies on the lysine requirement of chicks. Poultry Sci. *35*:385-390, 1956

Fisher, H., D. Johnson, Jr., and G. A. Leveille. The phenylalanine and tyrosine requirement of the growing chick with special reference to the utilization of the D-isomer of phenylalanine. J. Nutrition *62*:349-355, 1957.

Johnson, D., Jr., and H. Fisher. The amino-acid requirement of laying hens. 3. Minimal requirement levels of essential amino acids: techniques and development of diet. British J. Nutrition *12*:276-285, 1958.

Rosenberg, H. R. Methionine and lysine supplementation of animal feeds. Jour. Agr. and Food Chem. *5*:694-700, 1957.

Rosenberg, H. R., J. T. Baldini, and C. I. Tollefson. Histidine requirement of the growing chicks. Poultry Sci. *36*:1381-1382, 1957.

Scott, H. M. Observations on the amino acid requirements of chicks fed crystalline amino acids. Proceedings Cornell Nutrition Conf. for Feed Manufacturers, pp. 106-110, 1958.

Tsien, W. S., E. L. Johnson, and I. E. Liener. The availability of lysine from Torula yeast. Arch. Biochem. Biophys. *71*:414-422, 1957

Antibiotics

Stokstad, E. L. R. and T. H. Jukes. Further observations on the "animal protein factor." Proc. Soc. Exp. Biol. Med. *73*:523-528, 1950.

Biotin

Hegsted, D. M., R. C. Mills, G M. Briggs, Jr., C. A. Elvehjem, and E. B. Hart. Biotin in chick nutrition. J. Nutrition *23*:175-179, 1942

Calcium (and Phosphorus)

Bethke, R. M., D. C. Kennard, C. H. Kik, and G. Zinzalian. The calcium-phosphorus relationship in the nutrition of the growing chick. Poultry Sci. *8*:257-265, 1929.

DeWitt, J. B., R. B. Nestler and J. V. Derby, Jr. Calcium and phosphorus requirements of breeding bobwhite quail. J. Nutrition *39:567-577*, 1949.

Evans, R. J., and J. S. Carver. The calcium and phosphorus requirements of Single Comb White Leghorn pullets. Poultry Sci. *21:469*, 1942.

Nelson, F. E., L. S. Jensen, and J.McGinnis. Requirement of developing turkeys for calcium and phosphorus. Poultry Sci. In Press.

Norris, L. C., G. F. Heuser, A. T. Ringrose, and H. S. Wilgus. Studies of the calcium requirements of laying hens. Poultry Sci. *13:308*, 1934.

Wilgus, H. S. The quantitative requirement of the growing chick for calcium and phosphorus. Poultry Sci. *10:107-117*, 1931.

Choline

Evans, R. J. The choline requirements of turkey poults. Poultry Sci. *22:266-267*, 1943.

Gillis, M. B., and L. C. Norris. Vitamin B_{12} and the requirement of the chick for methylating compounds. Poultry Sci. *28:749-750*, 1949.

Lucas, H. L., L. C. Norris, and G. F. Heuser. Observations on the choline requirements of hens. Poultry Sci. *25:373-375*, 1946.

Record, P. R., and R. M. Bethke. Further observations on yeast and choline in chick nutrition. Poultry Sci. *21:271-276*, 1942.

Ringrose, R. C., and H. A. Davis. Choline in the nutrition of laying hens. Poultry Sci. *25:646-647*, 1946.

Schaefer, A E., W. D. Salmon, and D. R. Strength. Interrelationship of vitamin B_{12} and choline. II. Effect on growth of the chick. Proc. Soc. Expt. Biol. Med. *71:202-204*, 1949.

Feed Requirement

Almquist, H. J. Unpublished data on growth and feed consumption of turkeys. 1958.

Byerly, T. C. Feed and other costs of producing market eggs. Maryland Agr. Expt. Sta. Bul. A 1 (Technical), 1941.

Gannon, A. University of Georgia "Poultry Tips," Nov. 1957.

Maine Dept. of Agriculture, Augusta, Main Production and Broiler Test reports.

Rosenberg, H. R., and J. T. Baldini. Unpublished data on growth and feed consumption of broilers, 1958.

Scott, M. L. How fast do they grow and how much do they eat? Turkey World. January, 1957.

Folacin

Lillie, R. J., G. F. Combs, and G. M. Briggs. Folic acid in poultry nutrition. Poultry Sci. *29:115-129*, 1950.

Robertson, E. I., L. J. Daniel, F. A. Farmer, L. C. Norris, and G. F. Heuser. Folic acid requirement of growing chicks. Poultry Sci. *25:411*, 1946.

Scott, M. L., G. F. Heuser, and L. C. Norris. Studies in turkey nutrition using a purified diet. Poultry Sci. *27:770-772*, 1948.

Iodine

Scott, M. L., A. van Tienhoven, E. R. Holm, and R. E. Reynolds. Studies on the sodium, chlorine, and iodine requirements of young pheasants and quail. J. Nutrition *71*:282-288, 1960.

Wilgus, H. S., G. S. Harshfield, A. R. Patton, L. P. Ferris, and F. X. Gassner. The iodine requirements of growing chickens Poultry Sci. *20*:477, 1941.

Magnesium

Almquist, H. J. Magnesium requirement of the chick. Proc. Soc. Expt. Biol. Med. *49*:544-545, 1942.

Bird, F. H. Magnesium deficiency in the chick, a neuropathologic and biochemical study. PhD. Thesis, University of California, 1948.

Manganese

Gallup, W. D., and L. C. Norris. The amount of manganese required to prevent perosis in the chick. Poultry Sci. *18*:76-82, 1939.

Gallup, W. D., and L. C. Norris. The effect of a deficiency of manganese in the diet of the hen. Poultry Sci. *18*:83-88, 1939.

Gutowska, M. S., and R. T. Parkhurst. Studies in mineral nutrition of laying hens. The manganese requirement. Poultry Sci. *21*:277-287, 1942.

Niacin

Briggs, G. M., Jr., R. C. Mills, C. A. Elvehjem, and E. B. Hart. Nicotinic acid in chick nutrition. Proc. Soc. Expt. Biol. Med. *51*:59-61, 1942.

Briggs, G. M., Jr., T. D. Luckey, L. J. Teply, C. A. Elvehjem, and E. B. Hart. Studies on nicotinic acid deficiency in the chick. J. Biol. Chem. *148*:517-522, 1943.

Childs, G. R., C. W. Carrick, and S. M. Hauge. The niacin requirement of young chickens. Poultry Sci. *30*:551-558, 1952.

Scott, M. L. Prevention of the enlarged hock disorder in turkeys with niacin and vitamin E. Poultry Sci. *32*:670-677, 1953.

Scott, M. L. and G. F. Heuser. Studies in duck nutrition. 4. Bowed legs in ducks caused by niacin deficiency. Poultry Sci. *31*:752-754, 1952.

Sunde, M. L. The niacin requirement of chickens from 6 to 11 weeks. Poultry Sci. *34*:304-311, 1955.

Sunde, M. L. and H. R. Bird. The niacin requirement of the young Ringneck pheasant. Poultry Sci. *36*:34-42, 1957.

Pantothenic Acid

Baurenfeind, J. C., L. C. Norris and G. F. Heuser. The pantothenic acid requirement of chicks. Poultry Sci. *21*:142-146, 1942.

Gillis, M. B., G. F. Heuser, and L. C. Norris. Pantothenic acid in the nutrition of the hen. J. Nutrition *35*:351-363, 1948.

Hegsted, D. M., and R. L. Perry. Nutritional studies with the duck. V. Riboflavin and pantothenic acid requirements. J. Nutrition *35*:411-417, 1948.

Kratzer, F. H., and D. Williams. The pantothenic acid requirement of poults for early growth. Poultry Sci. *27:*518-523, 1948.

Waisman, H. A., R. C. Mills, and C. A. Elvehjem. Factors required by chicks maintained on a heated diet. J. Nutrition *24:*187-198, 1942.

Phosphorus (see also Calcium)

Gillis, M. B., L. C. Norris, and G. F. Heuser. The effect of phytin on the phosphorus requirement of the chick. Poultry Sci. *28:*283-288, 1949.

Miller, M. W., and G. E. Bearse. Phosphorus requirements of laying hens. Washington Agr. Expt. Sta. Bul. *306*, 1934.

Singsen, E. P., L. D. Matterson, and H. M. Scott. Phosphorus in poultry nutrition. III. The relationship between the source of vitamin D and the utilization of cereal phosphorus by the poult. J. Nutrition *33:*13-26, 1947.

Sullivan, T. W. Phosphorus requirements of turkeys for late growth. Poultry Sci. *38:*1252, 1959.

Sunde, M. L., and H. R. Bird. A critical need of phosphorus for the young pheasant. Poultry Sci. *35:*424-430, 1956.

Watkins, W. E. and H. H. Mitchell. The phosphorus requirements of growing chickens with a demonstration of the value of controlled experimental feeding. Poultry Sci. *15:*32-41, 1936.

Potassium

Ben-Dor, B. Requirement of potassium by the chick. Proc. Soc. Expt. Biol. Med. *46:*341-343, 1941.

Gillis, M. B. Potassium requirement of the chick. J. Nutrition *36:*351-357, 1948.

Protein

Baldini, J. T., R. E. Roberts and C. M. Kirkpatrick. A study of the protein requirements of Bobwhite quail reared in confinement in battery brooders to eight weeks of age. Poultry Sci. *29:*161-166, 1950.

Clandinin, D. R. Unpublished data on protein requirement of growing pheasants, 1959.

Heuser, G. F. Protein in poultry nutrition—A review. Poultry Sci. *20:*362-368, 1941.

Mussehl, F. E., C. W. Ackerson, and R. H. Thayer. Protein utilization by the growing poult. Poultry Sci. *20:*469, 1941.

Norris, L. C., L. J. Elmore, R. C. Ringrose, and G. Bump. The protein requirement of Ring-Necked pheasant chicks. Poultry Sci. *15:*454-459, 1936.

Roberts, R. E. Levels of protein in rations for young turkeys. Indiana Agr. Expt. Sta. Bul. *448*, 1940.

Scott, M. L., and G. F. Heuser. Studies in duck nutrition. 2. Studies of protein and unidentified vitamin requirements. Poultry Sci. *30:*164-167, 1951.

Scott, M. L., G. F. Heuser and L. C. Norris. Energy, protein, and unidentified vitamins in poultry nutrition. Poultry Sci. *27:*773-780, 1948.

Scott, M. L., E. R. Holm and R. E. Reynolds. Studies on pheasant nutrition. 2. Protein and fiber levels in diets for young pheasants. Poultry Sci. *33:*1237-1244, 1954.

Sunde, M. L. The energy and protein relationship for poultry. Proc. Seventh Nutrition School for Feed Men, U. Wisconsin, p. 67, 1956.

Pyridoxine

Briggs, G. M., Jr., R. C. Mills, D. M. Hegsted, C. A. Elvehjem, and E. B. Hart, The vitamin B_6 requirement of the chick. Poultry Sci. *21*:379-383, 1942.

Cravens, W. W., E. E. Sebesta, J. G. Halpin and E. B. Hart. Studies on the pyridoxine requirements of laying and breeding hens. Poultry Sci. *25*:80-82, 1946.

Hegsted, D. M., and M. N. Rao. Nutritional studies with the duck. II. Pyridoxine deficiency. J. Nutrition *30*:367-374, 1945.

Hogan, A. G., L. R. Richardson, H. Patrick, D. L. O'Dell, and H. L. Kempster. Vitamin B_6 and chick nutrition. Poultry Sci. *20*:180-183, 1940.

Riboflavin

Bethke, R. M., and P. R. Record. The relation of riboflavin to growth and "curled-toe" paralysis in chicks. Poultry Sci. *21*:147-154, 1942.

Boucher, R. V., H. Patrick, and H. C. Knandel. The riboflavin requirement of turkeys for hatchability and growth. Poultry Sci. *21*:466, 1942.

Boucher, R. V., F. W. Hill, H. Patrick, and H. C. Knandel The riboflavin requirement of turkeys for hatchability. Poultry Sci. *20*:456-457, 1941.

Davis, H. J., L. C. Norris, and G. F. Heuser. Further evidence on the amount of vitamin G required for reproduction in poultry. Poultry Sci. *17*:87-93, 1938.

Hegsted, D. M., and R. L. Perry. Nutritional studies with the duck. V. Riboflavin and pantothenic acid requirements. J. Nutrition *35*:411-317, 1948.

Heuser, G. F., H. S. Wilgus, and L. C. Norris. The quantitative vitamin G requirement of chicks. Poultry Sci. *17*:105-108, 1938.

Petersen, C. F., C. E. Lampman, and O. E. Stamberg. Effect of riboflavin intake on egg production and riboflavin content of eggs. Poultry Sci. *26*:180-186, 1947.

Petersen, C. F., C. E. Lampman, and O. E. Stamberg. Effect of riboflavin intake on hatchability of eggs from battery-confined hens. Poultry Sci. *26*:187-191, 1947.

Sodium and Chlorine

Scott, M. L., A. Van Tienhoven, E. R. Holm, and M. E. Reynolds. Studies on the sodium, chlorine, and iodine requirements of young pheasants and quail. J. Nutrition *71*:282-288, 1960.

Thiamine

Arnold, A., and C. A. Elvehjem. Studies on the vitamin B_1 requirements of growing chicks. J. Nutrition *15*:403-410, 1938.

Almquist, H. J. and E. Mecchi. Vitamin A requirements of laying hens. Poultry Sci. *18*:129-137, 1939.

Bearse, G. E., and M. W. Miller. The vitamin A requirements of White Leghorn pullets during the growing period. Poultry Sci. *16*:34-38, 1937.

Bearse, G. E., and M. W. Miller. The effect of varying levels of vitamin A in the hen ration on the vitamin A content of the egg yolk, on hatchability, and on chick livability. Poultry Sci. *16*:39-43, 1937.

Biely, J., and W. Chalmers. Vitamin A requirements of growing chicks. I. Preliminary studies with "Reference" cod liver oil, Can. J. Research, Sect. D., Zool. Sci. *14*:21-24, 1936.

Boucher, R. V., and H. C. Knandel. Vitamin A for poultry. Pennsylvania Agr. Expt. Sta. Bul. *367*:56, 1938.

Frohring, W. O. and J. Wyeno. Carotene and vitamin A requirements for White Leghorn chicks. J. Nutrition *8*:463-476, 1934.

Builbert, H. R., and W. R. Hinshaw. Vitamin A storage in livers of turkeys and chickens. J. Nutrition *845-56*, 1934.

Hinshaw, W. R. and W. E. Lloyd. Vitamin A deficiency in turkeys. Hilgardia *8*: 281-304, 1934.

Jungherr, E. Nasal histopathology and liver storage in subtotal vitamin A deficiency of chickens. Connecticut Agr. Expt. Sta. Bul. *250*, 1943.

McClary, C. F., G. E. Bearse, and V. L Miller. Vitamin A requirements of laying hens. Western Washington Agr. Expt. Sta. Ann. Rept. 45-46, 1939.

Nestler, R. B. Vitamin A vital factor in the survival of Bobwhites. Trans. 11th N.A. Wildlife Conf. pp. 176-195, 1946.

Record, P. R., R. M. Bethke, and O. H. M. Wilder. The vitamin A requirements of growing chicks. Poultry Sci. *14*:297, 1935.

Record, P. R., R. M. Bethke, and O. H. M. Wilder. The vitamin A requirements of chicks with observations on the comparative efficiency of carotene and vitamin A. Poultry Sci. *16*:25-33, 1937.

Ringrose, R. C. and L. C. Norris. A study of the vitamin A requirement of the chick during early life. Poultry Sci. *15*:390-396, 1936.

Rubin, M., and H. R. Bird. Relation of vitamin A to egg production and hatchability. Maryland Agr. Expt. Sta. Tech. Bul. *A12*, 1942.

Rubin, M., H. R. Bird and H. M. DeVolt. Avitaminosis A in commercial poultry flocks. Poultry Sci. *20*:155-160, 1941.

Rusoff, L. L. and N. R. Mehrhof. Shark liver oil—a potent source of vitamin A for poultry. Poultry Sci. *18*:339-344, 1939.

Russell, W. C., C. S. Platt, M. W. Taylor and D. F. Chichester. Vitamin A requirements of the laying pullet. New Jersey Agr. Expt. Sta. Circ. *369*, 1936.

Sherwood, R. M. and G. S. Fraps. The quantities of vitamin A required by pullets for maintenance and for egg production. Texas Agr. Expt. Sta. Bul. *468*, 1932.

Sherwood, R. M. and G. S. Fraps. The amount of vitamin A potency required by hens for egg production. Texas Agr. Expt. Sta. Bul. *468*, 1932.

Sherwood, R. M. and G. S. Fraps. The amount of vitamin A potency required by hens for egg production. Texas Agr. Expt. Sta. Bul. *493*, 1934.

Sherwood, R. M. and G. S. Fraps. The vitamin A requirement of hens for egg production. Texas Agr. Expt. Sta. Bul. *514*, 1935.

Sherwood, R. M. and G. S. Fraps. Requirements of chickens for vitamin A when fed as carotene. Texas Agr. Expt. Sta. Bul. *583*, 1940.

Taylor, M. W., and W. C. Russell. The provitamin A requirement of growing chicks. Poultry Sci. *26*:234-242, 1947.

Taylor, M. W., J. R. Stern, and W. C. Russell. The provitamin A requirement of hens. Poultry Sci. *26*:243-254, 1947.

Tepper, A. E. and R. C. Durgin. Vitamin A requirements of growing chicks. New Hampshire Agr. Expt. Sta. Bul. *310*, 1938.

Williams, J. K., C. E. Lampman, and D. W. Bolin. The efficiency of carotene as supplied by alfalfa meal in meeting the vitamin A requirements of laying hens. Poultry Sci. *18*:268-275, 1939.

Wilson, W. O., C. H. Schroeder, and W. A. Higgins. Further studies on the vitamin A requirements of chicks.. Poultry Sci. *15*:426, 1936.

Vitamin B_{12}

Chin, D., J. B. Anderson, R. F. Miller, L. C. Norris, and G. F. Heuser. The vitamin B_{12} requirement of White Leghorn hens. Poultry Sci. *37*:335-343, 1958.

Davis, R. L. and G. M. Briggs. Vitamin B_{12} requirement of the chick. Poultry Sci. *30*:628-629, 1951.

Fox, M. R. S., L. O. Ortiz, and G. M. Briggs. Effect of dietary fat on requirement of vitamin B_{12} by the chick. Proc. Soc. Expt. Biol. Med. *93*:501-504, 1956.

Miller, R. F., L. C. Norris, and G. F. Heuser. The vitamin B_{12} requirement of White Leghorn chicks. Poultry Sci. *35*:342-349, 1956.

Ott, W. H., E. L. Rickes, and T. R. Wood. Activity of crystalline vitamin B_{12} for chick growth. J. Biol. Chem. *174*:1047-1048, 1948.

Peterson, C. F., A. C. Wiese, G. E. Milne, and C. E. Lampman. Vitamin B_{12} requirements for hatchability and production of high quality chicks. Poultry Sci. *32*:535-542, 1953.

Vitamin D

Association of Official Agricultural Chemists. Official and tentative methods of analysis. 8th ed. The Association, Washington, D. C. 1955.

Baird, F. D. and D. J. Greene. The comparative vitamin D requirements of growing chicks, turkeys, and pheasants. Poultry Sci. *14*:70-82, 1935.

Bird, H. R. Comparison of response of turkey poults and of chicks to different forms of vitamin D. J. Nutrition *27*:377-383, 1944.

Boucher, R. V. Efficacy of vitamin D from different sources for turkeys. J. Nutrition *27*:403-413, 1944.

Fritz, J. C., W. Archer, and D. Barker. Vitamin D requirements of ducklings. Poultry Sci. *20*:151-154, 1941.

Hammond, J. C. The vitamin D requirements of turkey poults. Poultry Sci. *20*: 204-205, 1941.

Murphy, R. R., J. E. Hunter and H. C. Knandel. The vitamin D requirements of growing chicks and laying hens. Pennsylvania Agr. Expt. Sta. Bul. *334*, 1936.

Wilhelm, L. A., E. I. Robertson and M. Rhian. The effect of the level of vitamin D on egg production and hatchability of Bronze turkey hens. Poultry Sci. *20*: 565-569, 1941.

Vitamin E

Atkinson, R. L., T. M. Ferguson, J. H. Quisenberry, and J. R. Couch. Vitamin E and reproduction in turkeys. J. Nutrition 55:387-397, 1955.

Jensen, L. S., M. L. Scott, G. F. Heuser, L. C. Norris and T. S. Nelson. Studies on the nutrition of breeding turkeys. 1. Evidence indicating a need to supplement practical turkey rations with vitamin E. Poultry Sci. 35:810-816, 1956.

Vitamin K

Nelson, T. S. and L. C. Norris. Studies on the vitamin K requirement of the chick. 1. Requirement of the chick for vitamin K_1, menadione, and menadione sodium bisulfite. J. Nutrition, in press.

Zinc

Edwards, H. M., Jr., W. S. Dunahoo, and H. L. Fuller. Zinc requirement studies with practical rations. Poultry Sci. *38*:436-439, 1959.

Kratzer, F. H., P. Vohra, J. B. Allred and P. N. Davis. Effect of zinc upon growth and incidence of perosis in turkey poults. Proc. Soc. Exp. Biol. Med. *98*:205-207, 1958.

Morrison, A. B. and H. P. Sarett. Studies on zinc deficiency in the chick. J. Nutrition *65*:267-280, 1958.

O'Dell, B. L., P. M. Newberne, and J. E. Savage. Significance of dietary zinc for the growing chicken. J. Nutrition *65*:503-518, 1958.

Roberson, R. H. and P. J. Schaible. The zinc requirement of the chick. Poultry Sci. *37*:1321-1323, 1958.

Young, R. J., H. M. Edwards, Jr., and M. B. Gillis. Studies on zinc in poultry nutrition. 2. Zinc requirement and deficiency symptoms of chicks. Poultry Sci. *37*:1100-1107, 1958.

Zeigler, T. R., R. M. Leach, Jr. and L. C. Norris. Zinc requirement of the chick. Fed. Proc. *17*:498, 1958.

TABLE 1

Nutrient Requirements of Chickens[1]
(In Percentage or Amount per Pound of Feed)

	Starting chickens 0-8 weeks	Growing chickens 8-18 weeks	Laying hens	Breeding hens
Total protein, per cent	20	16	15	15
Vitamins				
Vitamin A activity (U.S.P. Units)[2]	1200	1200	2000	2000
Vitamin D (I.C.U.)[3]	90	90	225	225
Vitamin E	see text			
Vitamin K_1, mg.	*0.24*	?	?	?
Thiamine, mg.	0.8	?	?	?
Riboflavin, mg.	1.3	0.8	1.0	1.7
Pantothenic acid, mg.	4.2	4.2	2.1	4.2
Niacin, mg.	12	*5.0*	?	?
Pyridoxine, mg.	1.3	?	1.3	1.3
Biotin, mg.	0.04	?	?	?
Choline, mg.[4]	600	?	?	?
Folacin, mg.	0.25	?	0.11	0.16
Vitamin B_{12}, mg.	*0.004*	?	?	*0.002*
Minerals				
Calcium, per cent	1.0	1.0	2.25[5]	2.25[5]
Phosphorus, per cent[6]	0.6	0.6	0.6	0.6
Sodium, per cent[7]	0.15	0.15	0.15	0.15
Potassium, per cent	0.2	0.16	?	?
Manganese, mg.	25	?	?	15
Iodine, mg.	0.5	0.2	0.2	0.5
Magnesium, mg.	220	?	?	?
Iron, mg.	*9.0*	?	?	?
Copper, mg.	*0.9*	?	?	?
Zinc, mg.	*20*	?	?	?

[1] These figures are estimates of requirements and include no margins of safety. Underlined figures are tentative. See text, page 2

[2] May be vitamin A or pro-vitamin A.

[3] See text, page 3

[4] See text, page 4

[5] This amount of calcium need not be incorporated in the mixed feed, inasmuch as calcium supplements fed free choice are considered as part of the ration.

[6] At least 0.45% of the total feed of starting chickens should be inorganic phosphorus. All of the phosphorus of non-plant feed ingredients is considered to be inorganic. Approximately 30% of the phosphorus of plant products is non-phytin phosphorus and may be considered as part of the inorganic phosphorus required. A portion of the phosphorus requirement of growing chickens and laying and breeding hens must also be supplied in inorganic form. For birds in these categories the requirement for inorganic phosphorus is lower and not as well defined as for starting chickens.

[7] Equivalent to 0.37 per cent of sodium chloride.

TABLE 2

Nutrient Requirements of Turkeys[1]
(In Percentage or Amount per Pound of Feed)

	Starting poults 0-8 weeks	Growing turkeys 8-16 weeks	Breeding turkeys
Total protein, per cent[2]	28	20	15
Vitamins			
Vitamin A activity (U.S.P.)[3]	2400	2400	2400
Vitamin D (I.C.U.)[4]	400	400	400
Riboflavin, mg.	1.7	?	1.5
Pantothenic acid, mg.	5.0	?	7.3
Niacin, mg.	32	?	?
Choline, mg.	750	?	?
Folacin, mg.	0.4	?	0.35
Minerals			
Calcium, per cent	2.0	1.7	2.25[5]
Phosphorus per cent[6]	1.0	0.85	0.75
Manganese, mg.	25	?	15
Sodium, per cent[7]	0.15	0.15	0.15
Zinc, mg.	25	?	?

[1] These figures are estimates of requirements and include no margins of safety. Underlined figures are tentative. See text, page 2

[2] The protein content of rations for growing turkeys from 16 weeks to market weight may be reduced to 16 per cent.

[3] May be vitamin A or pro-vitamin A.

[4] See text, page 3.

[5] This amount of calcium need not be incorporated in the mixed feed, inasmuch as calcium supplements fed free choice are considered as part of the ration.

[6] At least 0.50% of the total feed of starting poults should be inorganic phosphorus. All of the phosphorus of non-plant feed ingredients is considered to be inorganic. Approximately 30% of the phosphorus of plant products is non-phytin phosphorus and may be considered as part of the inorganic phosphorus required. Presumably a portion of the requirement of growing and breeding turkeys must also be furnished in inorganic form.

[7] Equivalent to 0.37 per cent of sodium chloride.

TABLE 3

Essential Amino Acid Requirements of Chickens and Turkeys

Amino acid	Starting chicks Per cent of ration	Starting poults Per cent of ration	Laying chickens Per cent of ration
Arginine	1.2	1.6	?
Lysine	1.0	1.5	0.50
Histidine	0.3	?	?
Methionine	0.8	0.87	0.53
or			
Methionine[1]	0.45	0.52	0.28
Cystine	0.35	0.35	0.25
Tryptophan	0.2	0.26	0.15
Glycine[2]	1.0	1.0	?
Phenylalanine	1.4	?	?
or			
Phenylalanine[3]	0.7	?	?
Tyrosine	0.7	?	?
Leucine	1.4	?	1.2
Isoleucine	0.6	0.84	0.5
Threonine	0.6	?	0.4
Valine	0.8	?	?
For protein level	20.0	28.0	15.0

[1] Cystine will replace methionine for chicks as long as the ration contains not less than 0.45 per cent methionine.

[2] The chick can synthesize glycine but the synthesis does not proceed at a rate sufficient for maximum growth.

[3] Tyrosine will replace phenylalanine for chicks as long as the ration contains not less than 0.7 per cent phenylalanine.

TABLE 4

Nutrient Requirements of Ducks[1]
(In Percentage or Amount per Pound of Feed)

	Starting and growing ducks
Total protein, per cent	17
Vitamins	
Vitamin D (I.C.U.)[2]	100
Riboflavin, mg.	1.8
Pantothenic acid, mg.	5.0
Niacin, mg.	25
Pyridoxine, mg.	1.2

[1] These figures are estimates of requirements and include no margins of safety. Underlined figures are tentative. See text, page 2

[2] See text, page 3.

TABLE 5

Nutrient Requirements of Pheasants and Quail[1]
(In Percentage or Amount per Pound of Feed)

	Starting and growing pheasants	Starting and growing quail	Breeding quail
Total protein, per cent	30[2]	28[2]	?
Vitamins			
Vitamin A activity (U.S.P. Units)[3]	?	6000	?
Vitamin D (I.C.U.)[4]	225	?	?
Niacin, mg.	22	?	?
Minerals			
Calcium, per cent	?	?	2.3
Phosphorus, per cent	1.0	?	1.0
Sodium, per cent[5]	0.085	0.085	?
Chlorine, per cent	0.11	0.11	?
Iodine, mg.	0.14	0.14	?

[1] These figures are estimates of requirements and include no margins of safety. Underlined figures are tentative. See text, page 2
[2] At energy level of 750 Calories of productive energy per pound of feed.
[3] May be vitamin A or pro-vitamin A.
[4] See text, page 3.
[5] Equivalent to 0.21 per cent of sodium chloride.

TABLE 6

Feed Required by Chickens of Different Live Weights for Maintenance and for the Production of 0, 100, 200, and 300 Eggs, Respectively, per Year

Average Live Weight	Average Total Feed Required per Bird per Year for Maintenance and the Production of the Indicated Number of Eggs			
	0 Eggs per Year	100 Eggs per Year	200 Eggs per Year	300 Eggs per Year
Pounds	Pounds	Pounds	Pounds	Pounds
3.0	47	61	75	89
3.5	52	67	81	95
4.0	57	71	85	99
4.5	61	75	89	104
5.0	65	80	94	108
5.5	70	84	98	112
6.0	74	88	102	116
6.5	78	92	106	120
7.0	81	96	110	124

TABLE 7

Feed Required and Time Required to Obtain Certain Average Live Weights with Common Breeds of Chickens

Average live weight	Kind of chicken and quantity of feed required per bird				Kind of chicken and age at which certain live weights are reached			
	White Leghorns		Heavy Breeds		White Leghorns		Heavy Breeds	
	Females	Males	Females	Males	Females	Males	Females	Males
0.5	1.0	0.9	0.9	0.8	3.0	2.7	2.8	2.5
1.0	2.3	2.0	1.9	1.8	5.4	4.7	4.4	4.1
1.5	3.7	3.2	3.1	2.9	7.6	6.4	5.7	5.2
2.0	5.3	4.7	4.5	4.2	9.7	7.8	7.0	6.3
2.5	7.1	6.3	6.1	5.5	12.1	9.0	8.3	7.3
3.0	9.7	8.2	7.8	6.9	14.6	10.4	9.5	8.2
3.5	13.2	10.6	10.0	8.5	17.5	12.0	10.8	9.1
4.0	20.8		12.4	10.2	20.9		12.0	10.0

TABLE 8

Feed Required and Time Required to Obtain Certain Average Live Weights with Two Common Breeds of Turkey

Average live weight	Kind of turkey and quantity of feed required per bird				Kind of turkey and age at which certain live weights are reached			
	Beltsville Small White		Broad-Brested Bronze		Beltsville Small White		Broad-Breasted Bronze	
	Females	Males	Females	Males	Females	Males	Females	Males
Pounds	Pounds		Pounds		weeks	weeks	weeks	weeks
0.5	0.6	.6	.6	.6	2.5	2.2	1.9	1.7
1.0	2.0	1.9	1.5	1.5	4.5	4.0	3.3	3.1
2.0	4.9	4.5	3.5	3.2	7.0	6.3	5.3	4.9
3.0	7.9	7.1	6.0	5.2	9.1	7.9	6.6	6.2
4.0	10.9	9.6	8.5	7.8	10.9	9.3	7.8	7.3
5.0	14.1	12.4	11.2	10.2	12.7	10.7	9.1	8.2
6.0	18.4	15.1	14.4	12.7	14.6	11.8	10.3	9.1
8.0		21.6	21.2	18.2	20.5	14.0	12.7	10.7
10.0		29.5	30.0	24.7		16.3	15.1	12.3
12.0		41.1	40.9	31.6		19.6	17.5	13.9
14.0			53.3	38.5			20.3	15.7
16.0			70.1	46.3			24.4	17.3
18.0			94.8	54.4				18.9
20.0				63.5				20.7
22.0				72.9				22.3

TABLE 9

Daily Nutrient Requirements per Animal
(S.C. White Leghorns or similar breeds)

	Growing Animal						Mature Animal		
							Maintenance	Laying 60% Production	Breeding
Body weight, lb.	0.5	1.0	1.5	2.0	2.5	3.0	4.0	4.0	4.0
Total daily feed, lb.	0.056	0.095	0.119	0.139	0.161	0.189	0.156	0.241	0.241
Crude protein, lb.	0.011	0.019	0.024	0.022	0.026	0.030	?	0.036	0.036
Calcium, gm.	0.25	0.43	0.54	0.63	0.72	0.85	?	2.46	2.46
Phosphorus, gm.	0.15	0.26	0.32	0.38	0.43	0.51	?	0.66	0.66
Sodium, gm.	0.037	0.064	0.081	0.094	0.108	0.127	?	0.16	0.16
Potassium, gm.	0.050	0.086	0.108	0.101	0.115	0.136	?	?	?
Magnesium, mg.	12.3	20.9	26.2	?	?	?	?	?	?
Manganese, mg.	1.40	2.38	2.98	?	?	?	?	?	3.62
Iodine, mg.	0.028	0.048	0.060	0.028	0.032	0.038	?	0.048	0.120
Vitamin A, U.S.P. units	67.	114.	143.	167.	193.	227.	?	482.	482.
Vitamin D, I.C.U.	5.0	8.6	10.7	12.5	14.5	17.0	?	54.	54.
Thiamine, mg.	0.045	0.076	0.095	?	?	?	?	?	?
Riboflavin, mg.	0.073	0.124	0.155	0.111	0.129	0.151	?	0.241	0.410
Pantothenic acid, mg.	0.235	0.399	0.500	0.584	0.676	0.794	?	0.51	1.01
Niacin, mg.	0.67	1.14	1.42	0.70	0.80	0.95	?	?	?
Pyridoxine, mg.	0.073	0.124	0.155	?	?	?	?	0.31	0.31
Biotin, mg.	0.0022	0.0038	0.0048	?	?	?	?	?	?
Choline, mg.	33.6	57.0	71.4	?	?	?	?	?	?
Folacin, mg.	0.014	0.0238	0.298	?	?	?	?	0.027	0.039
Vitamin B_{12}, mg.	0.00022	0.00038	0.00048	?	?	?	?	?	0.00048

TABLE 10

Daily Nutrient Requirements per Animal
(Chickens of the Heavy Breeds)

	Growing Animal					Mature Animal		
							Laying	Breeding
						Maintenance	60% production	
Body weight, lbs.	0.5	1.0	1.5	2.0	3.0	5.5	5.5	5.5
Total daily feed, lbs.	0.074	0.119	0.152	0.178	0.213	0.192	0.276	0.276
Crude protein, lb.	0.015	0.024	0.030	0.036	0.045	0.029	0.041	0.041
Calcium, gm.	0.336	0.540	0.690	0.808	0.967	?	2.82	2.82
Phosphorus, gm.	0.201	0.324	0.413	0.484	0.579	?	0.751	0.751
Sodium, gm.	0.051	0.081	0.104	0.121	0.145	?	0.187	0.187
Potassium, gm.	0.068	0.108	0.138	0.162	0.194	?	?	?
Magnesium, mg.	16.3	26.2	33.4	39.2	46.9	?	?	?
Manganese, mg.	1.85	2.98	3.80	4.45	5.33	?	?	4.14
Iodine, mg.	0.037	0.060	0.076	0.089	0.107	?	0.055	0.138
Vitamin A, U.S.P. units	89.	143.	182.	214.	256.	?	552.	552.
Vitamin D, I.C.U.	6.7	10.7	13.7	16.0	19.2	?	62.1	62.1
Thiamine, mg.	0.059	0.095	0.122	0.142	0.170	?	?	?
Riboflavin, mg.	0.096	0.155	0.198	0.231	0.277	?	0.276	0.469
Pantothenic acid, mg.	0.31	0.50	0.64	0.75	0.89	?	0.58	1.16
Niacin, mg.	0.89	1.43	1.82	2.14	2.56	?	?	?
Pyridoxine, mg.	0.096	0.155	0.198	0.231	0.277	?	0.359	0.359
Biotin, mg.	0.0030	0.0048	0.0061	0.0071	0.0085	?	?	?
Choline, mg.	44.	71.	91.	107.	128.	?	?	?
Folacin, mg.	0.0185	0.0298	0.0380	0.0455	0.0533	?	0.030	0.044
Vitamin B_{12}, mg.	0.00030	0.00048	0.00061	0.00071	0.00085	?	?	0.00055