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Vitamins In Poultry Nutrition

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The field of knowledge on the subject of vitamins in poultry nutrition has become too broad to be covered adequately in one short paper. The practicing veterinarian is concerned chiefly with the symptoms of the various avitaminoses, differential diagnosis, methods of prevention and practical sources of the various vitamins to be used in either prevention or alleviation of the syndromes of each. In this paper, an attempt will be made to present some of this information in very brief form.

In alphabetical order, the vitamins of chief concern in poultry nutrition are A, B₁, B₂, or the G complex, D, E, K, and the anti-gizzard erosion factor. All of these vitamins are organic compounds, some of them known definitely and some of them not. However, they may all be classed into two general groups A, D, E, and K being fat soluble, while B₁ and B₂, or the G complex are water soluble, with the anti-gizzard erosion factor being questionable as to solubility.

Vitamin A

Vitamin A is necessary for both the chick and the laying hen. When this vitamin is lacking in the diet, the following symptoms may be expected:

(1) Loss of appetite.
(2) Failure to grow in chicks.
(3) Irregular and uncertain gait with marked tendency to sit down.
(4) Ruffled feathers and shaggy appearance.
(5) Deposits of urates in kidneys and ureters.
(6) Drying of conjunctivae accompanied by shrinking of lacrimal glands, followed by bacterial infection and cheesy deposits, known as nutritional roup.
(7) Pustules on lining of mouth and esophagus.
(8) Increased susceptibility to infections of the respiratory tract.
(9) In hens, decreased egg production, probably because of failure to ovulate.
(10) Decreased fertility and hatchability.
(11) Death.

It is to be remembered that varying degrees of vitamin deficiencies may occur, and further, that biological specimens very rarely behave in the prescribed manner. In other words, it is only the exceptional case which develops all phases of the typical syndrome. Frequently in chicks, in cases of severe vitamin A deficiencies only the loss in weight, wobbly gait, and death may be observed, although if many cases are examined, deposits of urates in the kidneys and ureters are usually observed. The pustules in the esophagus are usually absent in severe cases, but develop in chronic cases and more particularly in older birds. This is also true of nutritional roup, and a word of caution may be in order at this point. When the veterinarian is called to treat a flock of chickens or turkeys for roup, he will, if he is wise, determine just what the diet has been before attempting treatments for infectious types of roup.

Initial Symptoms

The initial symptoms, that is, failure to grow and the development of the unsteady gait, usually do not appear in chicks until they are four to five weeks old, and sometimes even later in life. This is chiefly because of the storage which the young chick carries over from the yolk of the egg from which he is hatched. The diet fed the mother hen will determine the amount of vitamin A reserve in the chick to a large degree.

In laying hens, severe deficiencies of vitamin A result in a cessation of egg pro-

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duction, nutritional roup, and death. Obviously, under practical conditions, all degrees of deficiency from very mild to complete absence of the vitamin may exist. In the marginal cases, there may be no external symptoms, yet the birds will be more susceptible to respiratory infections, and egg production will be decreased. If hatching eggs fail to hatch, the vitamin A content of the diet should be investigated.

Turkeys are more susceptible to vitamin A deficiencies than chickens. Cases of nutritional roup in flocks of turkeys are not rare, particularly in dry seasons.

Chemistry of Vitamin A

Vitamin A, as we know it today, is a hydrocarbon of the structure C₂₀H₈₀, and it is a nearly colorless substance. It exists as such only in animal sources, stored particularly in the liver, but the precursors of vitamin A, namely, alpha, beta, and gamma carotene and hydroxy-beta carotene or kryptoxanthine are found in vegetable sources also. These latter substances are utilized by the animal body and converted into vitamin A. Of these beta carotene is the most potent. Both carotene and vitamin A are destroyed by oxidation, particularly rapidly in higher temperatures, and feeds carrying vitamin A, must, therefore, be fed while fresh, and when stored, must be kept in cool places with as little air circulation as possible. The principal sources of vitamin A, then, are fresh green feed, dehydrated alfalfa, cod liver oil, or other fish liver oils which have been fortified with vitamin A, yellow corn, and egg yolk.

The unit of vitamin A used at present is the International Unit, which is growth promoting and has an antiophthalmic value of .0006 milligrams (.6 gamma) of pure beta carotene. The chick requires 1,000 to 1,200 International Units of vitamin A per pound of feed for adequate growth and protection, while the hen requires twice this amount, or 2,200 to 2,400 International Units per pound of total ration for optimum egg production and hatchability. The ration carrying 30 percent or more of a good grade of yellow corn, 5 percent of good quality, bright colored alfalfa, and one percent of a standard cod liver oil or its equivalent, will meet these requirements, and an ample supply is assured when the birds have access to fresh green range.

Vitamin B₁

Vitamin B₁ has been the subject of investigation since the time of Eykman, who observed a nutritional deficiency among his laboratory fowls as early as 1888, and by 1897 he had discovered that he could produce polyneuritis in fowls by feeding a diet of polished rice and that an aqueous extract of rice polishings cured the disease. The symptoms were staggering, loss of appetite, cessation of growth, retraction of the head with the birds turning cartwheels, dyspnea, cyanosis, slowing of the heartbeat (bradycardia) and finally death. Atrophy of the lymphoid tissue and enlargement of certain glands, such as the adrenals, thymus, testes, and thyroid may be observed.

Until comparatively recently, the term vitamin B was used to designate the entire group of vitamins included at present in the B-G complex, but work at Cornell, Ohio State, Wisconsin and California has done much to clarify this problem, although much confusion still exists. It is now certain that vitamin B₁ which has been identified chemically, and is also known as thiamin, is necessary for the prevention of polyneuritis in birds. There is very little storage of vitamin B₁ in the animal body, and the amount present in the egg yolk is dependent upon the diet of the hen. Therefore, this deficiency may be expected to appear somewhat earlier in chicks when the diet is lacking in B₁ and symptoms often appear in the second and third weeks after hatching.

Vitamin B₁ is present in the germ and the bran, or outer coats of grains, green feed, milk, egg yolk, and the richest source of all is brewers’ yeast, with

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wheat germ ranking second. The wide distribution of the vitamin among common feedstuffs fortunately makes B₁ deficiencies in common rations highly improbable, although present methods of manufacture, in which wheat germs are removed from the by-products wheat-bran and wheat middlings, reduce the B₁ content of these products very appreciably, and some outbreaks of polyneuritis have occurred in Iowa, particularly in turkeys.

In work at Wisconsin, it has been found that 90 to 115 International Units of vitamin B₁ per pound of feed protected chicks against polyneuritis, although there seems to be some breed difference in B₁ requirements, some of the heavy breeds having greater requirements than Leghorns.

**Vitamin B₂ or G**

The second fraction of the water-soluble group of vitamins, B₂ or G, was demonstrated by the Cornell group in 1929, when a peculiar paralysis in which the toes of the chicks curled inward was observed. Further work at that station, Ohio, Wisconsin, and California has demonstrated that B₂ or G is flavin, and it is known at present as riboflavin. This factor also prevents dermatitis in turkey poults, but not in chicks, and it is growth-promoting. Riboflavin is necessary for hatchability, and possibly for egg production. In flavin deficient diets, the hatchability may fall as low as ten percent or lower, whereas the addition of flavin promptly restores the hatchability to the normal level.

The Cornell group has proposed the unit of flavin as the growth promoting activity of .001 milligrams of flavin. On this basis, the chick apparently required about 1,300 units of flavin per pound of feed for normal growth, and the hen required about 1,050 units per pound of feed in order to produce eggs which will hatch well. On this same basis, with pork liver as a standard at 100, dried yeast carries 35 units per gram, dried whey, 30, dried skimmilk, 20, and dehydrated meal slightly less. Flavin is fairly stable to heat, particularly moist heat, while vitamin B₁ is destroyed by heat.

**Filtrate Factor**

Still another factor necessary for growth and for the prevention of dermatitis in chicks in the so-called filtrate factor which has been identified as panthenolic acid. This dermatitis appears as encrustations around the beaks, eyes and feet. Similar symptoms in turkey poults are not affected by the filtrate factor, but as previously stated, they are prevented by the feeding of flavin. Jukes has proposed as a unit for the filtration factor one-tenth the amount which would just provide for maximal growth when fed daily to a chick three weeks old in conjunction with a heated diet. Wheat germ, fresh kale, and corn are apparently about equal in their content of filtration factor.

**Vitamin B₄**

There is some question as to whether vitamin B₄ is necessary for chickens, although some work has been done which indicates that a peculiar flatfooted gait and partial paralysis may result if this factor is lacking. Some investigators feel that the symptoms ascribed to a deficiency of this factor may simply represent a chronic state of B₁ deficiency, while others believe that this factor is identical with that responsible for the prevention of nutritional encephalomalacia, or "crazy chick disease". In this disease, discolored spots are observed on the surface of the cerebellum, and there is a general edema of the brain, accompanied by paralysis. This syndrome is prevented by a protective factor in various vegetable oils, and by alpha-tocopherol (vitamin E) from vegetable oils. Norris suggests the feeding of roasted ground soybeans rather than the soybean oilmeal as a preventive for this condition. There is no need for further information on this factor.

**Vitamin B₆**

Vitamin B₆ is another anti-dermatitis...
factor, found in cane molasses, but it is still questionable as to whether it is required for chicks.

Although this is rather a long list of factors in the B-G complex, others have been proposed. The entire field is developing rapidly at present, and much of the confusion on the “vitamin G perplex”, as it has been so aptly termed by Almquist, will undoubtedly be clarified in the near future.

**Vitamin D**

Vitamin D is probably the best-known and most frequently discussed of all the vitamins. Absence of this vitamin results in crooked breast bones, enlarged joints, beaded ribs, failure of the bones to calcify, low calcium and phosphorus in the blood, enlarged parathyroids, and cessation of growth. In mature stock, egg shell texture is poor, production is decreased, and hatchability is very low. In short, vitamin D is concerned directly with mineral metabolism, controlling the calcium and phosphorus equilibrium in the blood stream and in the bone. While vitamin D is necessary for bone formation, the amount required by the individual depends upon the amount and upon the ratio of calcium and phosphorus, and no amount of vitamin D will compensate for severe deficiencies of either of these two mineral elements. Therefore, rickets may develop in the presence of ample vitamin D if either calcium or phosphorus is lacking. In this connection, the chick requires at least .75 percent of calcium and .50 of phosphorus for normal calcification, and it should be pointed out that these amounts are stated as calcium and phosphorus—not calcium oxide, phosphorus pentoxide or any other compound.

**Rickets**

Rickets has been defined by Parks as “a disturbance in the metabolism of the growing organism of such a nature that salt equilibrium, in particular as regards calcium and phosphorus, in the circulating fluid is disturbed, and lime salts no longer deposit in the bones.” The first symptom of rickets is usually a crooked breastbone, but crooked breastbones are not specific for rickets, since crooked breastbones accompany sub-optimum calcium-phosphorus relationships, mis-management, breeding (to a minor degree) and perosis. Perosis should not be confused with rickets. In perosis, or slipped tendons, calcification is normal, and blood calcium and phosphorus are normal, but there is a permanent deformity of the hock joint which is prevented to a large degree by the inclusion of manganese in the diet. Enlarged hock joints also accompany both rickets and perosis. From a clinical standpoint then, rickets can be diagnosed most accurately by a study of the diet and by the rubbery bones which develop in the advanced stages. If an accurate diagnosis is necessary, it may be obtained by ashing the bones, and for this purpose the tibia is usually employed.

In laying birds, the first symptoms of vitamin D deficiency are thin egg shells, a few soft-shelled eggs, paralysis of one or both legs, and finally cessation of production. The requirements of laying hens are approximately twice as high as those for chicks. The chick requires approximately 175 International Units of vitamin D per pound of feed, and the laying hen about 350. The requirements for turkey pouls have been stated to be ten times those of chicks, or 1750 International Units per pound of feed. These requirements are based upon the vitamin D from cod liver oil. There are several types of vitamin D recognized at the present time, but these are not all equally efficient for the chick.

**Sources of Vitamin D**

The common sources of vitamin D for poultry raisers are: first, and best when it is available, direct sunlight. However, during the fall and winter months there is insufficient sunlight, even if the birds were exposed to it directly, to supply their needs, and other sources must be used. The fish oils, both cod-liver and
sardine, are used very extensively. These may be used in either the "straight" form or the concentrated. Under a ruling of the U. S. Department of Agriculture, all fish oils sold as vitamin D supplements must carry at least 85 units per gram. The concentrates ordinarily carry 400 units per gram. Either form may be used, and the selection will depend upon the price per unit of D, bearing in mind that no oil should be purchased unless it carries the unitage of vitamin D in chick units stamped upon the drum.

Vitamin E

Vitamin E has been found to be essential for hatchability, and when it is absent there is a high embryonic mortality which may occur early enough to be apparent infertility. Lack of this vitamin causes permanent sterility in males. However, it is found in the germ of grains, particularly wheat, and in green feed, and the ordinary ration in which the natural grains are used, and the feed is fresh and wholesome, should carry sufficient vitamin E. Rancidity destroys this vitamin very rapidly, and this is an additional argument for the use of fresh feeds. There is no satisfactory basis for evaluating the quantitative requirements of the laying hen at the present time, and consequently no unit requirements can be stated.

Wheat germ oil is the most concentrated source of vitamin E, and this product has rather unfortunately been given wide-spread publicity as a preventive or cure for fowl paralysis or leucosis. Work at the experiment stations has not shown any beneficial effect of wheat germ oil either as a preventive or a curative agent for leucosis either by injection or by oral administration. Therefore, while vitamin E is necessary for hatchability the use of vitamin E concentrates as treatments for infectious diseases should be avoided until experimental evidence is available to justify this usage.

Vitamin K

Vitamin K, which is needed by the chicken to prevent hemorrhages, is found in fresh alfalfa and good grade alfalfa meal. This vitamin is fat-soluble, but here again there is little danger of a deficiency in practical rations in which alfalfa meal has been used.

Anti-gizzard Erosion Factor

The last in the group of vitamins which were mentioned earlier is the anti-gizzard erosion factor. An absence of this factor results in crater-like erosions in the lining of the gizzard. Mild cases of deficiency result in roughened and weakened areas in the gizzard lining. The economic significance of gizzard erosions is not clear, since there is evidence to show that this condition does not interfere with growth in chicks. These lesions have been observed in the gizzards of 18-day embryos, but rarely in adult stock. It has been reported by the California station that this condition is associated with a low cholic acid content of the bile. Various feedstuffs contain such factors as fresh young green feed, wheat bran, oats hulls, and rice bran.

Another growth factor has been discovered by the Cornell and California stations. This factor is apparently necessary for growth and reproduction but it has not been completely identified as yet. It is found in wheat by-products, yeast, milk, and liver. It is not stable in heat.

Summary

In summary then, the vitamins which are known to affect growth are A, B1, B2, or G, the filtrate factor, D, and a new growth factor reported but not yet identified. Those which affect egg production or hatchability or both are A, B2, or G, D, and E, while vitamin K and the anti-gizzard erosion factor are necessary for general well-being.

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