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Nutritional Requirements of the Dog

Discussion of Foodstuffs, Vitamins and Minerals

M. H. Wykoff, '46

FROM the teeth pattern and the simplicity of the digestive tract it is certain that the dog belongs to the carnivorous class of animals. The dog is often cited as an animal having a simple digestive tract as compared to the complexity of the ruminant digestive tract and herbivorous animals in general. For this reason it was long believed that the dog was dependent upon an exclusive diet of animal products. However, under domestication, especially in recent years, the dog has been submitted to radical changes in diet and it has been demonstrated that the dog can handle a diet containing large proportions of carbohydrates. Along with this idea many fallacies connected with the nutritional requirements of the dog have been done away with. Instead of being able to live only on a diet of meat he may subsist on a diet very much the same as that of his master.

Considerations

There are, of course, certain considerations to be made in feeding dogs. These are alterations in the diet made to compensate for such things as size, age, pregnancy, lactation and the amount of work done by the individual. For instance, young growing dogs have about twice the nutritive requirements as the adult.

The purpose of this paper is to present and discuss the nutritional requirements of the dog and the various foodstuffs, vitamins and minerals that must be incorporated in an adequate diet. In addition to this, the diseases that arise from

the deficiency of these elements in the diet will be discussed.

Carbohydrates

In the past it was believed that the dog was incapable of digesting starch, but research conducted on the digestive processes of the dog has revealed that the dog is able to digest starch, either cooked or raw, in large quantities. This is due to the intestinal amylase which is highly efficient. It is generally conceded that the saliva of the dog does not contain an amylolytic enzyme. It was pointed out by an experiment conducted by Berryman and Schlotthauer that dogs can be fed carbohydrates such as bread, potatoes and carrots over long periods of time without harmful results. It was also found in an experiment run in Australia that dogs can be adequately fed on a diet containing 25 per cent vegetable products, 50 per cent cereal products and 25 per cent protein.

In regard to the utilization of vegetable products, it has been established that the dog cannot efficiently deal with large amounts of cellulose; however, the dog may develop an intestinal flora that will enhance the digestion of cellulose. In any event the ration should not contain over 2 per cent vegetable fiber.

The advantages of including carbohydrates in the diet of the dog are that easily digested carbohydrates reduce the necessity of a breakdown of body proteins and that they supply heat and energy. Carbohydrates also aid in the metabolism of fat. The latter fact is exemplified by the commonly made state-

ment, "fats are burned in the fire of the carbohydrates."

The primary consideration in adding carbohydrates to the diet is to guard against infringement upon the other necessary nutrients. When carbohydrates are added on a caloric basis they should be present in amounts sufficient to provide 30 to 40 calories per pound of body-weight together with the calories produced by the fat in the diet. On such a percentage basis the diet could contain 70 per cent carbohydrate.

Carbohydrates are fed mainly in the form of bread, potatoes, rice and other cereals. When vegetables are used they should be ground finely in order to make the carbohydrate more available to the action of the digestive enzymes. This is necessary as the carbohydrate is contained in the cytoplasm of the cell and is protected by a wall of cellulose. Also, where large amounts of cereals are used, phosphorus should be added as cereals are deficient in this mineral, and if this deficiency is not rectified rachitis may result. This is of special importance in growing pups. The amount of carbohydrate should not in any event exceed 15 times the amount of fat present.

Fats

Fats are valuable in the diet for supplementation of the calorie intake, rendering the feed more palatable and acting as a vehicle for the fat-soluble vitamins. The dog can deal with a reasonable amount of fat in the diet. It is considered an error to omit fat from the diet. It makes no difference as to whether or not the fat is of animal or vegetable origin, as the dog seems to be able to handle each type in a highly efficient manner. Fat has also been shown to reduce the thiamin requirements. In experiments conducted by Fairbanks and Curzon, 3 times as much fat as was necessary was incorporated in the ration and the thiamin requirements were reduced $\frac{1}{3}$.

The fat content of the diet should be 5 to 12 per cent. Guiliani states that the fat-protein ratio should range from 1:3 to 1:4. The fat content may in some cases be raised to as high as 30 per cent when

a high calorie intake is needed. The ratio of fat to carbohydrate should be 1 part fat to 2 parts carbohydrate.

Fat adds quality and luster to the hair coat of the animal. It has been found that fat deficient diets may result in a dry, flaky dermatitis. Fat deficiency is encountered in the field most commonly where dry dog foods are fed. Such foods are deficient in fat for reasons such as storage qualities and difficulties in packaging. A mistake occasionally seen is the practice of some kennel owners who cook meat for their dogs and discard the fat that renders out. In reality they are discarding an important part of the ration.

Protein

The protein content of the canine diet is one of the most important parts of the ration to be considered. Protein is needed primarily for growth, repair of the body tissues and for reproduction.

There has been some controversy in regard to the dogs ability to utilize vegetable protein, but recent research has proven that the dog can get along fairly well on a diet containing plant proteins providing a sufficient variety is supplied. A few plant proteins are adequate. To cite one experiment, Lossl found that he could maintain dogs on rye protein. The main difficulty encountered with plant proteins is the deficiency in certain amino acids. Due to this fact certain authorities point out that 75 per cent of the protein in the ration should be of animal origin. It is also generally conceded that plant proteins are not as economical as animal proteins. Further difficulties encountered when feeding vegetable proteins arise from the fact that the proteins are enclosed by cellulose which the dog is unable to digest to any great extent.

Animal proteins are not all of the same quality. It has been proven that the proteins of whole milk and whole eggs are of the highest rank and that those of the kidney and liver are superior to muscle protein. It has been shown that raw milk is the best type for the dog. Elvehjen found that dogs did not do as well

when fed pastuerized or evaporated milk as they did when fed raw milk. Sour milk is more digestible than sweet milk. The addition of corn syrup and starches enhance the digestibility of milk. The proteins of milk are casein, lactalbumin and lactoglobulin. A ration containing 18 to 22 per cent casein will meet the protein requirements of most dogs. Supplements that might be added are the amino acids cystine and methionine.

In general the nutritive value of proteins may be decreased by cooking. This indicates that dogs will do better on a diet of raw meat than if their meat is cooked. A protein that is made more available by cooking is that of eggs. The reason for this is that the raw egg goes through the digestive tract too rapidly to be digested efficiently. Eggs should be either soft boiled or hard boiled when fed to dogs and they should be cooked at a simmering temperature for 25 minutes rather than hard boiled quickly. Muscle protein is deficient in calcium and vitamins A, D and B₁. Fish meal is inferior to meat scraps and powdered milk as a protein supplement.

Protein Ratio

The amount of protein necessary when expressed in relation to carbohydrate is 1 part protein to 2 to 4 parts carbohydrate. Morgan expresses this as a ratio between protein calories and calories from other foodstuffs. He recommends 1 calorie of protein for every 4 calories of nonprotein food for small breeds and 1 calorie of protein for every 2.5 calories of nonprotein food for large breeds. On a percentage basis 10 per cent protein, of which 75 per cent is of animal origin, meets all the needs of the dog. Otherwise the amount may be as high as 25 per cent. Growing dogs, pregnant and lactating bitches need an increase over the given amounts and this increase may be as much as twice the required amount for normal adult maintenance. The best guide to follow in adjusting the amount of protein in the diet is to consider the quality of the protein. By quality we refer to the amino acid content of the protein. There are at least 10 amino

acids that are essential in the diet which are: tryptophane, lysine, histidine, phenylalanine, leucine, isoleucine, threonine, methionine, valine and arginine. Arginine may permissibly be absent in the diet of the adult dog, but it is known to play an important role in the regeneration of blood. According to Schlotthauer, meat protein contains all the amino acids that are essential to normal growth, development and maintenance. The ratio of fat to protein in meat fed to animals is approximately 45:10. Horse meat and beef are utilized almost equally.

Protein Deficiency

Total protein deficiency results in emaciation and reproductive disturbances. Peptic and duodenal ulcers are also a result of protein deficiency. In general protein deficiencies are complicated by other dietary deficiencies. Specific deficiencies of certain amino acids have been studied. A deficiency of lysine and histidine is thought by some to be the cause of "fright disease." Cystine and methionine are related to the production of choline, hence a deficiency of these amino acids will result in a choline deficiency. Other deficiencies that are related to protein deficiency will be discussed under their special headings.

Vitamin A

Vitamin A is necessary for growth, appetite, digestion and reproduction. It is also necessary in the prevention of xerophthalmia, night blindness and respiratory diseases.

Dogs fed on a diet deficient in vitamin A were found to have their growth retarded. Growth was resumed at a normal rate when carotene was added to the diet. In addition to showing the relationship of vitamin A to growth, experiments also showed that the dog is able to change carotene to vitamin A. Other experiments demonstrated that an excess of vitamin A in the ration did not prevent canine distemper or have much effect on the course of the disease. Because of its action in maintaining normal epithelium, it is reasonable to believe that there should be less disposition to respiratory

diseases in dogs adequately supplied with this vitamin.

In the dog vitamin A deficiency is seen mainly as disturbances involving the eye. The things commonly seen are eczema of the margins of the lids, conjunctivitis, xerosis, superficial keratitis, and xerophthalmia. During the course of the deficiency it will also be noted that the animal has difficulty seeing in the dark.

The dog requires 70 to 80 international units of vitamin A per kg. bodyweight per day. This vitamin is found in fish liver oils, liver, green vegetables, kidney, hearts, tomatoes, carrots, eggs, butter and milk.

Vitamin B Group

Thiamine is needed to promote growth, a normal appetite and carbohydrate utilization. This highly thermolabile vitamin functions as a catalyst in the metabolism of carbohydrates. It has been an arbitrary question as to whether the deficiency of this vitamin causes the disease known as "canine hysteria," "fright disease" or "running fits." The production of this disease has been attempted by feeding diets deficient in thiamin, but nothing definite has been proven.

The symptoms of a thiamine deficiency are anorexia, loss of weight, debility, restlessness, photophobia, hyperesthesia, ataxia, muscular tenderness, rough haircoat due to edema of the skin and a peculiar position of standing with the head held low.

Requirements

The requirement of this vitamin in the dog is 10 to 25 micrograms per kg. bodyweight per day for growing dogs and 10 micrograms per kg. bodyweight per day for maintenance in the adult. Each pound of canned dog food should contain 125 micrograms of thiamine. In the case of dry dog food the requirement is 80 micrograms per 100 grams of dry food. This vitamin is found in rice polishings, dried yeast, liver, lean pork, wheat germ, milk, beef, eggs, carrots, tomatoes, whole wheat and citrus fruits.

Riboflavin is necessary for intracellular oxidations. The deficiency of this vitamin

results in muscular weakness in the hind quarters, dermatitis, discharge from the eye, conjunctivitis, corneal opacity, bradycardia, cardiac arrhythmia and hypochromic anemia. In severe conditions the animals go into coma and death follows shortly. On post-mortem examination yellow mottling of the liver and degenerative changes in the central nervous system are seen. This vitamin is found in liver, kidney, yeast, lean beef, eggs, greens, soya flour and various fruits and vegetables.

Riboflavin is necessary in the diet at the rate of 200 to 400 micrograms per 100 grams of ration. The dog requires 15 micrograms per kg. bodyweight per day for maintenance. In the growing dog the requirement is 30 micrograms per kg. body weight per day.

Nicotinic acid or niacin is the factor which prevents black tongue in the dog. The lack of this vitamin causes lack of appetite, loss in weight, reddening and ulceration of the mucous membranes of the mouth and tongue, diarrhea and death.

Birch found that after this disease had been produced, an injection of 10 mg. of niacin daily for 3 days followed by small daily doses would cure the disease. It was also found that a minimal dose of 10 mg. would cure the condition if it was not too severe. Daily amounts of .027 to .084 mg. per kg. body weight would not provide protection while 0.1 to 0.13 mg. per kg. gave complete protection for 12 weeks. The daily requirements are 0.20 to 0.25 mg. of nicotinic acid per kg. bodyweight for adults and 0.25 to 0.36 mg. per kg. for growing dogs. One pound of canned dog food should contain 4.3 mg. of nicotinic acid.

Pantothenic acid belongs to the soluble fraction of the vitamin B complex. This vitamin is commonly known as the chick antidermatitis factor. It occurs widely in nature.

This factor is necessary to the adult as well as to the young. The symptoms arising from a deficiency of this vitamin are tachycardia, bradycardia (less frequently), nausea, vomiting, intussusception and a drying and scaling of the skin.

These symptoms are suggestive of an impairment of the autonomic nervous system, especially the parasympathetic system. Scudi and Hamlin found that a deficiency of pantothenic acid was associated with fatty livers. The blood also showed lowered values in cholesterol, cholesterol ester, lipid P and total lipoids. Administration of pantothenic acid resulted in an increase of the fat content of the blood.

The daily requirement for the dog is 100 micrograms per kg. bodyweight.

Pyridoxine is also one of the soluble fractions of the vitamin B complex. It is found in yeast, lean meat, kidney, milk, molasses, legumes, cereals and wheat by-products.

The deficiency of this vitamin results in a failure to grow properly and a loss in weight. A microcytic hypochromic anemia also appeared. In addition to this, generalized convulsions were noted. Sometimes ulceration of the snout and tongue along with thickening of the ears is seen. Other observers have reported fatty liver, mottled thymus, and gastro-intestinal disorders from studies of artificially produced pyridoxine deficiencies.

The daily requirement for this vitamin is between 10 and 60 micrograms per kg. bodyweight.

Choline

Choline is necessary for the proper metabolism of fats. It is involved in the metabolism of phospholipids. Deficiency of this vitamin results in fatty infiltration and degeneration of the liver. The only clinical symptoms of this deficiency are loss of appetite and weight. The requirements of the dog for this vitamin vary with the protein in the diet as it can be synthesized from methionine and ethanolamine. The daily requirements appear to be 10 to 50 mg. per kg. bodyweight per day.

As a rule vitamin C is believed to be synthesized by the dog in adequate amounts to meet all of his requirements. The only time that additional amounts of this vitamin need to be added to the diet, is when, for some reason he is unable to synthesize it himself.

The general symptoms in this deficiency

are severe pains in the limbs, swelling of the metaphysis, subperiosteal hematocysts and anemia. The bone changes in this case are characteristic of scurvy and do not resemble rickets or polyarthrititis.

The symptoms are alleviated in the majority of cases when citrus fruit juices are administered. However, certain cases do not respond to therapy. Other cases appear to rectify themselves due to a reestablishment of the synthesis of vitamin C.

Vitamin D

Vitamin D is necessary in the diet to prevent rickets. Natural sources of this vitamin are fish liver oils, egg yolk and butter.

The symptoms of rickets in the dog are bowing of the legs, enlargement of the metaphysis and the costal rosary. It was recently demonstrated that there is a difference in the vitamin D requirements of male and female puppies, the former having the highest requirement.

It is said that the dog can store enough of this vitamin in his body from irradiation from the sun in the summer to last him through the winter. With a calcium phosphorus ratio of 1.2:1 a dose of 10 to 20 international units of vitamin D per kg. bodyweight is sufficient to meet all the requirements of the dog. Frederick states that 1.5 to 2 international units of vitamin D per kg. bodyweight per day will meet the requirements of adult dogs. An excess of this vitamin will produce vomiting and a bloody diarrhea.

Vitamin E

The deficiency of vitamin E shows up in young animals rather than in adults. This deficiency is more or less congenital because if it appears in the young, the mother must also be deficient.

The principal symptom of this deficiency is muscular dystrophy in the young. It has been found that the condition can be improved by administration of alpha-tocopherol acetate to the mother during gestation. The daily requirement appears to be 1 mg. alpha-tocopherol per kg. bodyweight.

Vitamin E is found mainly in the oils of seeds. Milk is deficient in the proper amount of this vitamin.

Vitamin K is synthesized by the dog to an extent sufficient to meet his requirements. As to date no deficiency has been reported.

Minerals

The most important constituents of the mineral fraction of the diet are calcium and phosphorus. The most satisfactory calcium-phosphorus ratio is 1.2:1. These 2 minerals are brought into the diet by incorporation of milk, soft bones, bone meal and blood meal. The excess or deficiency of either calcium or phosphorus will produce rachitis. In fact, the calcium level may be so high that the resultant vitamin D requirements are brought up to the point where it is impossible to prevent rachitis. The chief mineral-containing foods for the dog are flesh, viscera residue from meat extract plants, fish, milk and milk derivatives.

In addition to these minerals the dog also needs sodium, chlorine, potassium, and iodine. There is also a probable need for manganese, cobalt and zinc. Iron and copper are also indispensable. The requirements for iron are 1 to 3 mg. per kg. of bodyweight per day. Copper should be present in the diet at the rate of 0.02 to 0.06 mg. per kg. of bodyweight per day. These minerals are present in liver in large amounts. The other minerals are generally brought into the diet with the other foodstuffs so that supplementation is not necessary. Iron and copper deficiencies are probably the only ones met with to any extent other than calcium and phosphorus. This deficiency is seen clinically as a hypochromic anemia.

Summary

As stated at the beginning of this article, dogs can receive adequate nutrition from fairly large amounts of carbohydrates. The cellulose content should, however, be kept at a minimum as the dog can not digest it to any great extent.

There should be an adequate amount

of fat incorporated in the diet. The dog can use the same fats as can be used by man.

The protein content of the diet should meet the amino acid requirements of the dog. Plant proteins may be used with no harmful effects with the exception of cottonseed meal which is toxic to dogs. As much of the animal protein as possible should be fed raw.

The dog requires nearly the same vitamins that man does. The only 2 that the normal dog does not need are vitamins C and K, as he is normally able to synthesize these in sufficient amounts.

The minerals needed by the dog should not be overlooked in forming the ration, especially in young or pregnant animals. Bone meal, soft bones and milk products make good mineral supplements.

The Biological Photographic Association will hold its sixteenth annual meeting at the Hotel La Salle in Chicago, September 5, 6 and 7. Experts in the fields of biological and clinical photography will give illustrated talks on new developments in methods and equipment. Techniques of still and motion-picture photography, copy, and photomicrography, will be discussed. Informal discussions will be held for the purpose of exchanging ideas and information. The work of many of the leading biological photographers will be on display in the salon, and new materials and equipment will be shown in the technical exhibit.

The Biological Photographic Association, a non-profit organization, was formed in 1931 to raise the standards of photography in teaching and research and to act as a clearing house for information on photographic methods. Its members are professional scientific photographers, scientists with an interest in photography as applied to their fields and designers of precision equipment.

Approximately 90 per cent of the casualties due to lightning occur in rural communities.