

The Diet of the Dog*

By CARL F. SCHLOTTHAUER.¹

BIOLOGICALLY dogs are classified as carnivora but it has long been recognized that they can subsist on either meat or a cereal diet. They commonly are maintained on about the same kinds of foods as are available for man. The kind of food frequently is controlled by certain environmental factors. In the Arctic, where vegetables and cereals are relatively scarce and many dogs are used for transportation, dogs commonly subsist on fish and meat because these foods are most available, whereas in warmer climates and especially in most of the large cities, vegetables, cereals and fruits are more abundant and dogs frequently are maintained on practically meatless diets.

Numerous hypotheses and opinions as regards the correct diet for dogs have emanated from various sources. Some of them are mere speculation, but many are based on careful observation and experimental investigation. Many papers dealing with various phases of canine nutrition have appeared in the literature. Excellent general discussions were presented recently by Ivy¹, Arnold and Elvehjem², Agnes Fay Morgan³, Koehn⁴, and Frederick and Robinson⁵. I shall not attempt to present a comprehensive review of the literature. It is the purpose of this paper to present some of the pertinent facts concerning canine nutrition. The observations of workers in the Division of Experimental Medicine of the Mayo Foundation and elsewhere will be cited.

The ideal diet has been defined by Voit⁶ as a palatable mixture of foodstuffs arranged together in such proportions as to burden the organism with a minimum of labor. According to Lusk⁷, "A foodstuff is a material capable of being added to the body's substance, or one which when absorbed into the blood stream will prevent or reduce the wasting of a necessary constituent of the organism." He listed the following materials as foodstuffs: proteins (including albuminoids), carbohydrates, fats, salts and water.

Undoubtedly, protein is one of the most important materials in foodstuffs. Rubner⁸ stated that "Protein contains the magic of life, ever newly created and then dying, a process continuous since the advent of life upon the earth."

It is generally agreed that the ratio of protein to carbohydrates and fats combined should be between 1:2 and 1:4. The quantity of the protein necessary in the diet is determined by its quality. The nutritive value of any protein is directly dependent upon its constituent amino acids, ten of which are essential for normal growth, development and maintenance.

¹ Division of Experimental Medicine, Mayo Foundation, Rochester, Minnesota.

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Proteins must be broken up into their constituent amino acids before they can be absorbed from the alimentary canal. According to Dukes⁹ one of the following fates awaits the amino acids after they are absorbed: (1) deamination, with the formation of urea and the oxidation of the carbon hydrogen residue; (2) synthesis into living material; (3) utilization for some specific purpose such as formation of hormones, bile salts, pigments and catalyts. Lusk stated that the biologic value of a protein is determined by the number of parts of body protein that are spared by 100 parts of the food protein. Urea is the principal end product of protein metabolism; thus the biologic value of a protein can be determined by measuring the nitrogen excretion of the animal. Since meat protein contains about 16 per cent nitrogen or 1 gm. of nitrogen for each 6.25 gm. of protein, each gram of nitrogen excreted indicates that 6.25 gm. of protein has been destroyed in the body.

Dogs can maintain themselves on an exclusive diet of protein if it contains all the essential amino acids, but in the absence of the single amino acid, tryptophan nitrogen equilibrium cannot be attained. Secondly, when protein alone is ingested the nitrogen loss from the body is not checked until an excess is supplied. When an animal receives an excess of protein, the nitrogen excretion rises, but not all the protein is lost, because some of it may be utilized as body fuel, thus saving the body fat, and after the nitrogen is split off from the protein molecule, the non-nitrogenous residue may be converted into glucose and finally into glycogen and fat.

Frederick and Robinson stated that dog foods containing 10 per cent of protein, not less than 75 per cent of which is of animal origin, will give excellent results. Since meat protein contains all the amino acids essential for normal growth, development and maintenance, it is an excellent source of protein for canine diets. Meat alone is digested readily by dogs and they can subsist on an exclusive meat diet, but an exclusive meat diet may be undesirable from the standpoint of economy. And too, a heavy meat diet is favorable for a putrefactive type of intestinal flora. This is a frequent cause of foul odors which emanate from the digestive tract. Frost, Butterworth and Farr¹⁰ in discussing this condition in man stated that diet alone cannot be depended on to re-establish a fermentative or normal type of flora. They mentioned that massive doses of *Lactobacillus acidophilus* taken regularly with milk will establish it as the predominant intestinal organism with beneficial clinical results. I have found that in the dog, the occurrence of a putrefactive type of intestinal flora usually is corrected or can be prevented by increasing the carbohydrate content of the diet.

Cohnheim¹¹, Hosoi, Alvarez and Mann¹², and Childrey, Alvarez and Mann¹³ stated that in the dog, meat is digested best when it is given in the form of lumps. When raw meat was fed in the form of lumps, amounts as large as 175 gm. for each kilogram of body weight were digested thoroughly, whereas, when finely ground meat was given, a large increase in the amount ingested resulted in an increase in the percentage of undigested faecal residue. It was noted also that raw meat was handled better than cooked meat. But in certain abnormal conditions

of the digestive system, cooked meat is handled with greater efficiency than raw meat. This has been discussed by Ivy.

Milk and milk products are an excellent source of protein to supplement diets for dogs. Casein commonly is used as a source of protein in various synthetic diets. But it is deficient or low in methionine and cystine and when it is used as a sole source of protein, the addition of methionine or cystine to the diet will enhance growth. Milk is also deficient in iron and when it is used as an exclusive diet or is given with other iron-free foodstuffs, nutritional anaemia will develop. Apparently the quantity of iron required by the dog is small. Experiments conducted at this institution by Berryman and me¹⁴ showed that when young dogs were given a diet of bread and milk in iron pans, anaemia did not develop during seven months. Iron commonly is present in various plants, the drinking water and the soil. The danger of iron deficiency therefore is quite remote under average feeding conditions.

The digestibility of milk and milk products was studied at this institution by Hosoi, Alvarez and Mann and by Childrey, Alvarez and Mann. They found that milk in amounts as large as 90 gm. for each kilogram of body weight was well tolerated and digested by dogs. In only a few instances were undigested curds present in the faecal residue. Sour milk was digested better than sweet milk. There was no apparent difference in the digestibility of raw and boiled milk, but condensed milk was not digested as well as fresh milk. When bread and other foods such as meat, potatoes, raw eggs and corn syrup were added to the milk a decrease in the milk residue was noted.

Hosoi, Alvarez and Mann found that cottage cheese was digested well, but grated Swiss cheese was digested hardly at all. Childrey, Alvarez and Mann later found that when Swiss cheese was fed in the form of lumps, it was digested well.

In general, milk products are a highly satisfactory source of proteins for the diet of dogs.

Eggs have a high protein content and are of animal origin, but they are not a highly satisfactory food for dogs. Childrey, Alvarez and Mann found that when raw egg albumin was ingested by a dog, it ran through the digestive tract so rapidly that much of it was unchanged. Soft-boiled and hard-boiled eggs were digested much better. Raw whole egg produced a residue of 35 to 60 per cent in which the egg albumin was altered only slightly. The discharges were foul, foamy and liquid. But when other food materials were mixed with raw egg, digestion was enhanced. A mixture of milk and raw egg was digested better than milk alone.

Fish have long been used as food for dogs in certain regions of the world and it has been shown that dogs can subsist on a fish diet. Raw or cooked fish and various fish products are used to supplement diets for dogs. But the recent experiments of Koehn indicate that fish meal is inferior to meat scraps or powdered milk as a protein supplement. We at this institution have not had experience in the use of fish in diets for dogs, but we have used both raw and canned fish in cat foods and have found them satisfactory for this animal.

Proteins from vegetable and cereal sources are digested readily by the dog, but they commonly are deficient in certain essential amino acids. However, it has been demonstrated that certain mixtures of plant proteins are adequate for the normal maintenance of dogs. Koehn was able to maintain dogs in a normal state of health and condition on a diet composed of yellow corn, wheat shorts, peanut meal, bone meal, limestone and sardine oil. This was fed both raw and cooked. He stated that cooking increased the efficiency of the various foods about 30 per cent and also made them more palatable.

The energy requirements of dogs vary with age, weight and activity. The accepted standard on the caloric requirements of a dog as determined by Cowgill¹⁵ is 70 to 80 calories per kilogram of body weight per day. This is applicable for a dog of a given weight and age only, because a growing puppy and a pregnant or lactating female require more than a maintenance allowance of food. Arnold and Elvehjem stated that growing puppies require about twice as much food as can be predicted by the maintenance values for good requirements of mature dogs. They also called attention to the fact that the caloric requirement per kilogram of body weight decreases as the body weight increases.

Since carbohydrates and fats are a cheaper source of energy than proteins, and since carbohydrates have a protein-sparing action, they should be incorporated in all diets permitting their use. The ability of the dog to digest starch was long a moot question but it now is known definitely that dogs can digest starch almost completely when it has been cooked. Childrey, Alvarez and Mann found that cooked starch gave faecal residues of less than 10 per cent whereas raw cornstarch was almost wholly undigested.

Experimental investigations have shown that various cereals and vegetables may be incorporated in diets for dogs. Hosoi, Alvarez and Mann found that cooked farina, rice and bread were digested well. Cooked rice appeared to be digested almost perfectly. Bread gave larger moist residues than either rice or farina. The digestion of all three of these cereal foods was enhanced when they were mixed with milk. Koehn used yellow corn, wheat shorts, wheat bran, peanut meal, soy bean meal and cottonseed meal in diets. Cottonseed meal was found to be toxic for dogs and therefore is unsuitable. In our kennels we commonly use commercially prepared cracker meal and sugar as the chief source of carbohydrates in the diets for dogs used in metabolism studies. Our stock diet for all dogs that do not require special foods is composed of yellow corn, oatmeal, wheat shorts, meat scraps and salt. This is cooked in a covered boiler and attains the consistency of moist corn bread. The dogs receiving this diet are given a ration of raw horse meat on one day of each week. This apparently supplies all the essential vitamins not included in the cooked food because we have not observed any condition attributable to dietary deficiency since this dietary regimen was inaugurated more than twelve years ago. Puppies and young growing dogs receive milk in ad-

dition to this diet. We commonly use a mixture of milk and corn syrup to supplement the diet of dogs that are in poor condition.

Dogs will tolerate the feeding of various vegetables and fruits, but in general, vegetables and fruits are not highly digestible. Cooking makes them more palatable and enhances digestion. Childrey, Alvarez and Mann found that potatoes, stewed tomatoes, corn and beets, baked bananas and stewed prunes were digested poorly and gave residues varying between 30 and 75 per cent. The addition of milk or gravy to these foods improved digestion. Mashed potatoes were not as digestible as potatoes fed in the form of lumps. Berryman and I fed dogs a diet of cooked potatoes and carrots with skim milk. This maintained the dogs in an apparently normal state of health but digestion of the potatoes and carrots was poor, as indicated by the large stools which commonly resembled masses of cooked carrots.

Hosoi, Alvarez and Mann found that raw bananas were the most poorly digested of all foods studied. Childrey, Alvarez and Mann learned that the digestibility of bananas was improved only slightly by baking. Baked bananas left a rather constant residue of about 37 per cent.

Prunes frequently are used to supply iron in diets. They are quite palatable to the dog but must be fed sparingly as they tend to have a laxative effect when given in large quantities.

Fats in general are composed of triglyceride esters of fatty acids, phospholipids and sterols. The physiologic functions of these compounds are various. It is thought that the main function of the glycerides is to provide a source of energy. The physiology of the phospholipids and sterols is not so well understood, but the latter seem to play a definite rôle in the formation of various hormones.

In animal nutrition we are interested chiefly in the energy value of fats. Fat has an energy value of 9.3 calories per gram, which is twice that for either carbohydrates or proteins. It also is the only food that is stored dry in the body, and a large proportion of the total energy store of the body is in the form of fat.

The fat requirements of an animal vary with age and activity. Animals will grow normally when they receive diets containing only a small quantity of fat, but growth is retarded seriously by feeding fat-free diets. Frederick and Robinson suggested that a range of 2 to 4 per cent of fat in the diet is perhaps best suited for all types of dogs.

The digestibility of fat in the form of lard and butter was studied by Hosoi, Alvarez and Mann. They found that they could easily reach the limits of digestion. Large quantities always produced large foul-smelling stools. Ten grams per kilogram of body weight appeared to be about as much as the dog's digestive system would tolerate. Amounts larger than this gave rise to vomiting and diarrhoea. They observed that when lard was mixed with other foodstuffs it apparently retarded emptying of the stomach and some foodstuffs were digested better when mixed with fat.

The vitamin requirements of dogs have been studied by many workers. I shall not attempt to discuss these studies in this paper. It is

recognized that these requirements are influenced by various factors. Mellanby¹⁶ observed that certain cereals, especially oatmeal, have an anti-vitamin substance that tends to inhibit calcification. The age, condition, weight and activity of the dog also play an important rôle in vitamin requirements. As stated in a previous paragraph, in our kennels a ration of raw horse meat once each week apparently supplied adequate vitamins for our dogs receiving our standard cooked diet. We use cod liver oil to supply vitamins A and D in various special diets. In diets prepared to furnish a minimum of fat, we use canned tomatoes to supply vitamin A and irradiated brewers' yeast for vitamin D. Brewers' yeast is also used to furnish the vitamin B complex in all diets requiring its use. Tomato juice also is rich in vitamin C. There are some indications that it is beneficial in certain cases. We have found that it will prevent the occurrence of sore mouth (gingivitis) in dogs receiving certain synthetic diets.

The consistent occurrence of hysteria or other similar nervous symptoms has not been observed in association with the feeding of various deficient diets at this institution.

Hosoi, Alvarez and Mann and later Childrey, Alvarez and Mann noted that when food was given to an animal at hourly or half-hourly intervals, it passed through the digestive tract more rapidly and the residues were larger than when all the food was given at a single feeding each day. This would appear to favor the conclusion that feeding a dog once a day is better than more frequent feedings. Peters¹⁷ in his monograph on the Eskimo Dog mentioned that the Eskimos commonly feed their dogs not more than twice each week. This, however, is done to accustom their dogs to irregular feeding so that they do not become unmanageable when food is scarce. I do not advise such long intervals between feedings but I do believe that commonly dogs are fed more often than is necessary or good for them. In our kennels we feed all adult dogs only once each day. After all, the jackal, wolf and fox may not eat as often as that and they seem to enjoy good health.

The feeding of dogs may be summarized by stating that dogs are facultative omnivora. They can subsist on various diets composed of foodstuffs of either animal or plant origin. But, from the standpoint of health and economy a mixture of foodstuffs containing at least 10 per cent of protein, most of which is of animal origin, and 2 to 5 per cent of fats incorporated in a suitable cereal and vegetable mixture is recommended. My general recommendation to the owners of canine pets is that they feed some meat and any cereals and vegetables that are available provided the dog will eat and tolerate them. The latter can be determined by trial only.

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