Digestibility of Pet Foods

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Traditionally, pet food advertising called the buyer's attention to certain features of a product such as superior flavor, a more agreeable texture, the convenience of the package, or the cost of feeding the product. Lately, superior digestibility has been added to that list, and the production of minimal fecal volume is seen as a virtue in dog foods. The CVMA Pet Food Certification Program uses digestibility of the product as part of its monitoring program, so the attention that manufacturers are now paying to that aspect of pet food, is welcome.

Digestion is the first stage in the conversion of food substances (nutrients) into animal tissues. The gastrointestinal tract is a specialized extension of the exterior surface which is designed to facilitate the hydrolysis and absorption of complex food ingredients such as proteins, fats and carbohydrates. The process of digestion is usually thought of as a series of discreet events and it is easy to gain the impression that they happen in isolation, one from the other. In fact, digestion is a series of processes which happen simultaneously in the same region(s) of the gastrointestinal tract, and may interfere with one another. These interferences are the basis for a phenomenon known as "associative effects", and explains why the digestibility of single sources of a nutrient are greater than when the nutrient is provided in a mixed diet.

The process of digestion comprises two phases: one which occurs in the lumen of the intestine, in which hydolytic enzymes attack specific sites of the food molecules to produce similar units. The second phase of digestion occurs right at the surface of the mucosal cell. In the lumenal phase of digestion, interference with digestion can occur if competing molecules either attract or bind a nutrient in an indigestible form. An example would be the forming of insoluble calcium fat complexes when high levels of calcium are present with fats. Mechanical interference with the movement of the products of lumenal digestion to the mucosal surface for final digestion may occur as well. An example of this latter type of interference is the effect of high levels of dietary fibre on the digestion of proteins. The contact phase of digestion is also subject to mechanical interference when sites become clogged with molecules which resist digestion and are not available. Overprocessing of proteins may produce reaction products of carbohydrates and certain amino acids such as lysine, which fit into this category of inhibitors of digestion. Since nutrients are streaming past sites of final digestion and absorption, if these sites are blocked, the nutrients will be swept past and may be lost.

Digestion is affected by the rate of passage of the chyme or digesta through the tract and by the condition of mucosa. The rate of passage of digesta in dogs and cats is rather faster than noted for species such as humans or swine. The fact that these animals have digestion rates of some 80 to 90% of proteins and fats, is an indication of the efficiency of their digestive system. Despite that efficiency, any factor which increases the rate of passage will have an adverse effect on the digestibility of a food. Such factors may include stress, high levels of fiber, fatigue, infection, and immune responses within the GI tract. Included in the definition of "fiber" for many pet foods are things besides cellulose, such as the gums used very frequently in canned foods to control texture or to confer a gelled appearance.

There are two types of digestibility: apparent and true. The apparent digestibility is the one most frequently used in both literature and in advertising. To determine apparent digestibility, a panel of dogs or cats are fed the test food for several days (usually 10) to avoid errors due to problems with the animal becoming adjusted to the food.

The animals are given a food blended with an indigestible marker dye. This marker dyes the stomach content to mark the start of fecal material associated with the food eaten on the first day of the test. The diet is continued for the next three days. On the fifth day the animal is again given a meal which contains the dye to mark the contents of the stomach. The appearance of the dye in the feces marks the appearance of digesta which was associated with the end meal. Feces are collected three times per day starting with the appearance of the dye and collection ends with the appearance of dye associated with the fifth day meal. The food intake for the four days of the trial is recorded and samples of the food are retained. The food and feces are analyzed for the nutrient(s) of choice (marked as "X" below). Apparent digestibility is calculated as follows:

$$\text{Apparent digestibility } (\%) = \frac{(\text{Food total X}) - (\text{Fecal total X})}{(\text{Food total X})} \times 100$$

The fecal content of any nutrient X is not entirely attributable to food nutrient X because the sloughing of cells, microbial activity, and GI secretions may all contribute to the fecal content of that nutrient X. This contribution is known as "endogenous loss" and can be determined by measuring the loss of nutrient X when the animal is fed a diet free of that nutrient. The amount of loss measured is the level that would appear in the feces and is not attributable to the diet. When the fecal level of that nutrient X is adjusted for the zero intake level, the resultant digestion is called true digestion. True digestion is calculated as follows:

$$\text{True digestibility} = \frac{(\text{Food total X}) - (\text{Fecal total X} - \text{Endogenous X})}{(\text{Food total X})} \times 100$$

In normal animals, the difference between these values of true and apparent digestibility for protein and fat is minor, ranging from 1.60 to 18.75% of the apparent values. The difference between true and apparent digestibility, at levels of nutrients usually found in normal diets, is about 2.15 to 3.33% of the apparent value. In practical terms, the difference between true and apparent digestibility is within the normal error of determination for digestibility. The CVMA Pet Food Certification Program uses apparent rather than true digestibility because the methods are more reliable in most instances, and there are only small differences between apparent and true digestibility.

The efficiency of digestion by dogs and cats is fairly good. The overall protein digestibility of commercial dog foods is about 75% for dry foods and better than 85% for moist foods. The level of digestion for dry matter is usually 5 to 8% less than the digestibility of protein. The digestibility of fats is usually about 90% in both types of foods. The numbers cited were for a mixed diet and one may find that the digestion of single nutrient feeding may be either greater or less than that noted for mixed diets.

There has been interest in recent years in the ability of dogs to digest a variety of byproduct materials because of the need to extend the range of materials available in pet diets. Dogs have been reported (1) to be able to digest dried brewers grains (52 to 62%) and even acid detergent fiber at the rate of 11 to 33%. The digestion of fiber may very likely occur in the cecum and upper large gut by means of bacterial action. Other writers (2) present evidence that the digestion of energy by dogs is adversely affected by the inclusion of such things as dried brewers grains and beet pulp, which significantly depressed the digestibility of energy in dog foods. The inclusion of grape and tomato pomace likewise has a strong negative effect on the digestion of energy and dry matter. Kendall *et al* (1) reported that dogs digested 90% of the starch in rice, corn or oats, irrespective of whether these products were cooked or not. This is at variance from the conventional wisdom that dogs require all cereals to be cooked.

Fats are generally well digested by all pets irrespective of the source. On the other hand, the digestibility of protein sources varies widely. The protein in meat scrap which contains a large amount of connective tissue is about 75% digestible, while soy protein is 85% digestible and that found in most meats is 90% or more digestible (3). The protein in feather meal is only about 20% digestible by dogs (4).

The effect of fiber level on digestibility is minimal, up to about 5 to 7% of the diet (3, 5) and it is unusual for commercial pet foods to contain more than that level. The adverse impact of high levels of dietary fiber is most noticed in marginal diets where even minimal effects will be important. This is due to either the minimal nature of the sources of nutrients, or the marginal level of nutrients.

Since digestion appears to be reasonably good for many of the nutrients, is there any reason to be concerned? Why is the annual check on digestibility important in the CVMA Pet Food Certification Program? The answer is that pets eat combinations of foodstuffs or nutrients which have been processed together. There are certain interactive effects which may either improve the digestion of the nutrient or may have an adverse effect. These "associate" effects are not easily predicted and substitution of ingredients may adversely affect digestion, and therefore the availability of nutrients. There may be no reason to suspect in advance that the substitution would be anything but innocent. Processing and changes in processing affect the availability of nutrients by a number of means ranging from outright destruction, to forming insoluble compounds which are not digestible. An example would be the crosslinking of lysine caused by heating a protein to high temperatures, or the formation in reaction products between carbohydrates and proteins at high cooking temperatures. Many of these changes are subtle and are not intended by the manufacturer to deliberately alter the product. They do occur and could over time, have an adverse effect on the nutritional quality of pet foods. The insistence of ongoing testing as part of the CVMA Program is the public's assurance that the product will continue to exhibit a level of digestibility, consistent with the provision of adequate levels of nutrients to the pet.

References

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