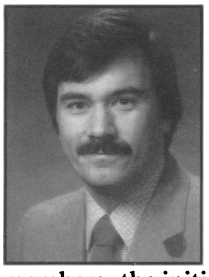
Carbohydrates in the nutrition of the dog

John Hilton



By far the most organic compound on the earth is the carbohydrate cellulose. The name carbohydrate was assigned to various sugars because it was thought that they followed the general formula $C_n(H_2O)_n$ (1). However, when more structural determinations were made of the other various group members, the initial hypothesis regarding formulation was dropped, yet the name for the group has remained.

The basic subunits of carbohydrates are simple sugars. The most important simple sugar is glucose and it makes up a large component of the other types of carbohydrates. The other more complex carbohydrates can be classified as mono-, di-, tri-, oligo-, and polysaccharides depending upon the number of simple sugars that they contain within a polymer chain. By convention, the simple sugars are called monosaccharides, those carbohydrates continuing just two simple sugars are called disaccharides, and all those carbohydrates which have in excess of two subunits of simple sugars in their polymer chains are referred to as polysaccharides. While there is a great variety of carbohydrates, the number that is encountered at significant levels in the common feedst uffs and feeds of dogs is usually quite small.

The carbohydrates commonly found in dog foods are: lactose, sucrose, starch, cellulose, hemicellulose.

Digestion of carbohydrates

The most common types of carbohydrates found in dog foods are the di- and polysaccharides. Moreover, the largest single type of carbohydrate found in foods is starch and this carbohydrate is generally considered to be the most economical way of supplying dietary energy in a feed or food (in comparison to protein and lipids). Starch is usually supplied to a dog by way of plant feedstuffs such as corn, rice and wheat, and thus it is not surprising to note that these ingredients are quite common in dog foods. Moreover, they are usually found at high levels of inclusion (>100 kg/tonne). It should be noted that whereas the carbohydrate starch is defined, the starch from corn does not have exactly the same structure as that from wheat.

John Hilton, CVMA Nutrition Subcommittee, Technical Manager — Animal Nutrition, Hoffmann — La Roche Limited.

TABLE 1. The digestibility of various types of carbohydrates in dogs

Carbohydrate	% Digestibility	Reference
Glucose	99	
Sucrose	99	(2)
Lactose	0–60	(2)
Potato starch[a]		(3)
— raw	19	
— cooked	84	
Maize starch[a]		(3)
— raw	47	
— cooked	84	
Hemicellulose	47	(4)
Cellulose	6–31	(5)
		(6)

[a]Assuming starch gross energy = 16.7 kj/g

That is why it is possible to have different starch digestibilities from different plant sources, as indicated in Table 1.

In general, cooked starch in practical-type or commercial dog foods is well digested with percentages usually in excess of 90% (7).

The digestibility of lactose in Table 1 is listed as 0 to 60% (2). It should be noted that this was determined using fistulated and intact dogs and represents ileal lactose digestibility. The apparent digestibility of lactose is much higher (99%) due to colonic microbial fermentation. Thus it is not surprising that some dogs can be lactose intolerant, and high levels of dietary lactose from milk products such as whey can lead to digestive disturbances such as diarrhea (8). However, the intake of small quantities of lactose (<5% of total calories) should be well tolerated by most animals (9).

It has been reported that the carbohydrate cellulose is also partly digested by dogs (5,6). In this regard it should not be concluded that the dogs in and of themselves can digest cellulose. This apparent digestibility no doubt results from microbial fermentation in the hindgut which may provide an additional, but slight, source of dietary energy to the dog (10).

Dietary carbohydrate utilization

Despite the variety of carbohydrate sources that can be eaten and digested by dogs, the greatest majority of these carbohydrates are digested and/or broken down into the simple sugar glucose, which is very efficiently absorbed across the intestinal tract. Glucose is

physiologically very important as an energy source as well as supplying carbon skeletons for the biosynthesis for other compounds in the dog. However, despite the very important physiological importance of glucose, there is no known minimum dietary requirement for carbohydrates in dogs. If the diet contains a sufficient supply of other nutrients such as proteins (amino acids) and glycerol, the dogs can biosynthesize a sufficient amount of glucose by way of the process of gluconeogenesis. For example, Beagle puppies fed carbohydrate-free diets all maintained normal blood glucose concentrations and growth rates or weight gain (11,12) in comparison to those fed carbohydrate.

There have been reports that the inclusion of certain levels of dietary carbohydrates may be beneficial to certain types of dogs. During gestation and lactation there is an increased need for glucose. Rosmos *et al.* (13) noted a reduced number of live pups at birth and the three days after birth in bitches fed carbohydrate-free diets. The effect has been attributed to severe hypoglycemia in the bitches at whelping. In contrast, Blaze et al (14) noted no differences in the ability of carbohydrate-free diets to support Beagle and Labrador bitches through pregnancy and lactation. It is possible that the higher dietary protein levels of the latter study helped to supply an adequate level of glucose through the gluconeogenic process.

On the basis of the previous discussion, dietary carbohydrates are not an essential part of the dog's diet. However, in terms of feed processing and supplying of an efficient and cost-effective dietary energy source, carbohydrates such as starch are very important. The ability to extrude a dog food (kibble feeds) and to provide a sufficient gel in a canned food requires the input of a significant level of carbohydrate. Thus carbohydrates are one of the most important dietary factors in a dog food supplying energy as well as the physical characteristics allowing for effective processing-manufacturing.

Carbohydrates are one of the most important dietary factors in a dog food supplying energy as well as the physical characteristics allowing for effective processing-manufacturing

Dietary Fiber

Dietary fiber is loosely defined as that part of the plant material which resists digestion, due to the absence of the cellulase enzyme in mammalian digestive systems (15). The latter definition notwithstanding, there is, as indicated in Table 1, some fiber digestion in dogs. Moreover, there is renewed interest in dietary fiber as of late in both human and canine nutrition and foods. This is because of the potential health benefits that increased dietary fiber may have. In addition, increased levels of dietary fiber have been used in so-called "Lite" foods as a way of reducing weight in obese dogs. Fiber levels in the common dog foods range from 2 to 4%.

However, the new "Lite" foods can contain from 5% to in excess of 20% dietary fiber. These levels of dietary fiber can increase the bulk of the food and depress gastric emptying (16). Thus, the dog achieves a full food feeling with a much lower dietary energy intake. In contrast, the intestinal transit of chyme from high fiber diets is relatively rapid (10). Moreover, high fiber diets have been shown to reduce the digestibilities of protein, carbohydrates and fat to the dog (10). Thus, the inclusion of high levels of dietary fiber can reduce nutrient bioavailability. Considering our lack of knowledge about specific nutrient bioavailability to dogs (essential fatty acids, etc.), the use of such high fiber diets as a weight-control measure is not without some potential risk, and should never be fed long-term to dogs. Furthermore, they should never be fed to young growing animals, or any animal under some physiological stress or disease state.

References

1. Rochrig KL. Carbohydrate Biochemistry and Metabolism. Westport, Conn.: AVI Pub. Co. Inc. 1984.
2. Schunemann C, Mukium A, Meyer H. International Symposium: Nutrition, Malnutrition and Diet of Dogs and Cats. Institute for Animal Nutrition. Tierarytliche Hochschule Hannover, 1987: 11.
3. Meyer HC, Schunemann C, Elbers H, Junker S. International Symposium: Nutrition, Malnutrition and Diet of Dogs and Cats. Institute for Animal Nutrition. Tierarytliche Hochule Hannover 1987: 13.
4. Visek WJ, Robertson JB. Proc Cornell Nutrition Conference, 1973: 40–49.
5. Moore ML, Fottler HJ, Fakey GC, Corbin JE. Utilization of corn-soybean meal-substituted diets by dogs. J Anim Sci 1980; 50: 892.
6. Burrows CF, Dronfeld NS, Banta CA, Mewitt AM. Effects of fiber on digestibility and transit time in dogs. J Nutr 1982; 112: 1726.
7. Heiman V. Nutrition and feeding of dogs. Feedstuffs 1959; February 14: 18–22.
8. Bennet MJ, Coon E. Mellituria and postprandial blood sugar curves in dogs after ingestion of various carbohydrates with the diet. J Nutr 1966; 88: 163.
9. Burger IH. A basic guide to nutrient requirements. In: Edney ATB, ed. Dog and Cat Nutrition. 2nd ed. Pergamon Press, 1988: 9–34.
10. Banta CA, Clemens ET, Krinsky MM, Sheffy BE. Sites of organic acid production and patterns of digesta movement in the gastrointestinal tract of dogs. J Nutr 1979; 109: 1592.
11. Belo PS, Rosmos DR, Leveille FA. Influence of diet on glucose tolerance, on the rate of glucose utilization and on gluconeogenic enzyme activities in the dog. J Nutr 1976; 106: 1465.
12. Rosmos DR, Selo PS, Bennink MR, Bergen WG, Leveille FA. Effects of dietary carbohydrates, fat and protein on growth, body composition and blood metabolites in the dog. J Nutr 1976; 106: 1452.
13. Rosmos DR, Palmer HJ, Muirari KL, Bennink MR. Influence of a low carbohydrate diet on performance of pregnant and lactating dogs. J Nutr 1981; 111: 678.
14. Blaza SE, Bolles N, Burger IH. Is carbohydrate essential for lactation and pregnancy in dogs? Proc 1985 Walthan Symposium No. 7. Cambridge University Press, 1988.
15. Van Soest PJ. Dietary fibres: Their definition and nutritional properties. Am J Clin Nutr 1978; 31: 21.
16. Holt S, Heading RC, Carter DC, Prescott LF, Tothill P. Effects of gel fibre on gastric emptying and absorption of glucose and paracetamol. Lancet 1979; 24: 636.