# Cats and Carbohydrates: Implications for Health and Disease

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***Abstract:*** *It has been suggested that high-carbohydrate diets contribute to the development of feline diabetes and obesity. The evidence does not support this. Healthy cats efficiently digest and metabolize properly processed starches and complex carbohydrates. Dietary carbohydrate can efficiently meet cats' cellular requirement for carbohydrate (glucose), sparing protein that would otherwise be needed for gluconeogenesis. Excess calories, regardless of source, contribute to obesity and obesity-related problems, but low-carbohydrate, high-fat diets pose a greater risk for obesity. The increasing prevalence of feline diabetes appears to be due to obesity and aging rather than to dietary carbohydrates. However, once cats become diabetic, consumption of a high-protein, low-carbohydrate diet may be beneficial.*

There is a perception among some pet owners and veterinarians that high-carbohydrate diets can be detrimental to the health of cats.[1–4] While the term *high carbohydrate* has not been defined, most authors refer to the amount of carbohydrate found in commercial dry pet food, which ranges between 4.5 and 13.5 g/100 kcal metabolizable energy (ME), as "high." Most commonly, dietary carbohydrates are suggested as contributing to the increasing prevalence of feline diabetes mellitus and obesity.[1,4] This article explores the evidence regarding the effects of dietary carbohydrates on cats.

## Are cats able to digest and use dietary carbohydrates?

Cats, like all mammals, derive energy from the oxidation of three macronutrients: protein, fat, and carbohydrate. The specific fuel used depends greatly on the diet consumed.[5] Cats evolved consuming low-carbohydrate diets, but their digestive system and metabolism can readily adapt to higher carbohydrate intakes. The suggestion that cats may have difficulty adapting to high-carbohydrate meals appears to be based on two observations: (1) cats lack glucokinase, an enzyme used to phosphorylate glucose inside cells, and (2) cats lack salivary amylase and, compared with dogs, may have lower activities of the enzymes involved in carbohydrate digestion.[6]

For glucose to be used by a cell, it must enter the cell and be phosphorylated. In most species, glucokinase is the enzyme responsible for this function after a meal. Lacking glucokinase activity, cats rely on other enzymes, including hexokinase.[7] Although hexokinase is less efficient than glucokinase when glucose concentrations are high, cats have considerably more hexokinase, as well as greater phosphofructokinase and pyruvate kinase enzyme activities, than dogs.[7]

There are different forms of dietary carbohydrate, including simple sugars, rapidly and slowly digested starches, and dietary fibers. Proper processing or cooking is necessary to make starches digestible for mammals, including cats. It has been shown in many species that poorly digestible carbohydrates or an overload of simple carbohydrates (sugars) may induce adverse changes in intestinal metabolism.[6] This is also true for cats given high quantities (25% to 40% of the diet) of raw (indigestible) starch or osmotically active sugars. However, when properly processed starches and carbohydrates from whole grains are provided as a major component of balanced diets, cats are able to digest and use them, with an average apparent digestibility exceeding 90%.[8,9] Thus, while cats may metabolize carbohydrates differently than dogs and other species, healthy cats are easily able to digest and metabolize dietary carbohydrate.[7–9]

## Why do cats need carbohydrate?

Healthy cats do not require dietary carbohydrate.[8] However, although carbohydrate is not an essential dietary nutrient, carbohydrate in the form of glucose is physiologically

essential. Most cells in the body normally use glucose as their primary energy source. Some cells can use alternative energy sources, but others, especially those in the brain, need a continuous supply of glucose. Glucose is so critical to survival that numerous systems are in place to ensure a consistent supply on a cellular level. In most species, dietary carbohydrate is used as a ready source of glucose to meet cellular demands. When dietary carbohydrate is not provided in sufficient quantities, dietary protein is used as the primary source for glucose via gluconeogenesis. However, protein or amino acids used for gluconeogenesis are not available to support protein synthesis and protein turnover.

Studies published in the 1970s and 1980s established that cats have a limited ability to alter their rate of protein catabolism and oxidation.[10,11] This has been interpreted as a biologic mandate for cats to use protein to maintain blood glucose levels even when sources of protein are limited and dietary carbohydrate is provided.[4] However, more recent in vivo studies have found that cats adapt to different protein and carbohydrate intakes. Using indirect calorimetry and isotopic studies of protein turnover, researchers confirmed that cats are readily able to increase or decrease protein oxidation in response to alterations in protein intake as long as the minimum requirement for protein is met.[5,12,13] Thus, when protein was low (14% of ME) and carbohydrate high (47% of ME), dietary carbohydrate provided a protein-sparing effect and protein oxidation was reduced.[13] Likewise, metabolism of carbohydrate increased as dietary carbohydrate increased.

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## Do excess carbohydrates cause obesity?

Obesity results when an animal's caloric intake exceeds its caloric needs. Carbohydrate consumed in excess of energy needs is converted for storage. First, glycogen stores are filled. The remaining carbohydrate must be converted into fatty acids before being stored in adipose tissue. De novo synthesis of triglycerides is approximately three times greater in mice fed a high-carbohydrate diet than in those fed a high-fat, low-carbohydrate diet, suggesting that excess carbohydrates may contribute to obesity.[14] However, total fat deposition was 2.5 times greater when the high-fat diet was fed; thus, this study actually shows a reduced risk for obesity when carbohydrates replace some of the fat in the diet.[14] Although this type of study has not been conducted in cats, other data suggest that cats would respond similarly.[15–18]

Because 100% of dietary energy comes from protein, fat, and carbohydrate, a reduction in one of these energy sources, by necessity, causes one or both of the remaining sources to increase proportionally. While protein may vary, low-carbohydrate diets typically contain increased fat, whereas high-carbohydrate diets typically are lower in fat and, hence, have a lower caloric density. Epidemiologic research in cats has documented an obesity-protective effect from high-carbohydrate, low-fat diets, while high-fat foods are associated with an increased risk for obesity.[15,16] Recent prospective studies further demonstrated that cats fed high-carbohydrate diets had less body fat and were less likely to become obese than those fed high-fat diets.[17,18] The obesity-promoting effects of fat increased as dietary fat exceeded 25% of ME.[18]

## Do excess carbohydrates cause diabetes mellitus in cats?

It has been suggested that high-carbohydrate diets could increase the risk for diabetes mellitus in cats.[1,19] As summarized by Rand and coworkers,[19] "consumption of excessive amounts of highly refined, easily digestible carbohydrates places a large, prolonged demand on the β cells for excessive insulin secretion, which eventually results in β-cell exhaustion and diabetes." However, the feline pancreas is less responsive to glucose and more responsive to amino acids as secretagogues, which is not consistent with this theory.[20] Although experimental diets containing up to 40% simple sugars (e.g., sucrose, glucose) did induce glucosuria and hyperglycemia, similar results were not found when starches or complex carbohydrates were used at a similar level.[8,9,21]

Multiple studies in healthy cats have confirmed that neither resting glucose concentration nor insulin sensitivity is adversely affected by increased dietary carbohydrate from starches and grains.[8,22,23] Further, recent research shows that dietary carbohydrate has even less of an impact on post-

prandial glucose and insulin responses in healthy cats than in dogs or humans.[9] Additionally, results of intravenous glucose tolerance testing in healthy cats fed low-carbohydrate, high-fat diets demonstrated significantly elongated glucose clearance, reduced acute insulin response, or greater total insulin area under the curve compared with cats fed higher-carbohydrate, lower-fat diets.[8,22] Therefore, it does not appear that dietary carbohydrate is a causative factor in diabetes. Rather, advancing age and obesity due to an inactive lifestyle and excess calorie intake are the greatest risk factors for diabetes mellitus.[19]

## Why are low-carbohydrate diets recommended for cats with diabetes mellitus?

While healthy cats are able to readily use carbohydrates in good-quality diets, diabetic cats may not be able to do so. The blood glucose concentration results from a balance between glucose entering the blood (either from gluconeogenesis or absorption from the diet) and the rate of cellular glucose uptake through insulin-mediated and non–insulin-mediated mechanisms. Replacing dietary carbohydrate with protein may be an effective means of slowing the release of glucose into the bloodstream. Numerous clinical studies have confirmed a benefit of high-protein, low-carbohydrate diets for diabetic cats, with decreased insulin requirements or enhanced glycemic control when the cats were fed a high-protein diet.[24–27] In fact, a number of diabetic cats that received high-protein (10 to 15 g protein/100 kcal ME), low-carbohydrate (1.7 to 3.5 g/100 kcal ME) diets along with insulin therapy were able to discontinue exogenous insulin altogether.[24,26,27]

## Conclusion

Properly cooked carbohydrates in a nutritionally complete and balanced diet are readily digested and used by healthy cats with no adverse effects. When dietary carbohydrate intake is low, protein intake must be increased to support gluconeogenesis as well as normal protein synthesis. Dietary carbohydrates can support physiologic glucose needs without the need for excess protein for gluconeogenesis. Many low-carbohydrate diets are high in fat, which may increase the risk for obesity. Excess calories, whether from fat, protein, or carbohydrate, contribute to obesity and obesity-related problems. The increasing prevalence of feline diabetes appears to be due to obesity and aging rather than to carbohydrates in the diet. However, once cats become diabetic, consumption of a high-protein, low-carbohydrate diet may be beneficial.

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