Effect of dietary insoluble fiber on control of glycemia in cats with naturally acquired diabetes mellitus

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Objective—To evaluate effects of dietary insoluble fiber on control of glycemia in cats with naturally acquired diabetes mellitus.

Design—Randomized controlled crossover trial.

Animals—16 cats with naturally acquired diabetes mellitus.

Procedure—Cats were fed a diet high in insoluble fiber (HF) containing 12% cellulose (dry-matter basis) or a diet low in insoluble fiber (LF) for 24 weeks; they were fed the other diet for the subsequent 24 weeks. Caloric intake and insulin treatment were adjusted to maintain stable body weight and control of glycemia, respectively. Cats were allowed an adaption period of 6 weeks after initiation of a diet, after which control of glycemia was evaluated at 6-week intervals for 18 weeks. Variables assessed included serum glucose concentration measured during the preprandial state, blood glycated hemoglobin concentration, serum glucose concentration measured at 2-hour intervals for 12 hours beginning at the time of the morning insulin injection, 12-hour mean serum glucose concentration, and mean fluctuation in serum glucose concentration from the 12-hour mean serum glucose concentration.

Results—Mean daily caloric intake, body weight, or daily insulin dosage did not differ significantly between cats when fed HF and LF diets. Mean preprandial serum glucose concentration, most postprandial serum glucose concentrations, and the 12-hour mean serum glucose concentration were significantly lower when cats consumed the HF diet, compared with values when cats consumed the LF diet.

Conclusions and Clinical Relevance—These results support feeding a commercially available diet containing approximately 12% insoluble fiber (dry-matter basis) to cats with naturally acquired diabetes mellitus. (*J Am Vet Med Assoc* 2000;216:1082–1088)

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Dietary fiber plays an integral role in the management of diabetes mellitus. Improved control of glycemia in diabetic humans[1-3] and dogs[4,5] has been documented after an increase in daily fiber consumption. Proposed beneficial effects of fiber consumption include delaying gastric emptying, decreasing carbohydrate absorption from the intestinal tract, increasing insulin sensitivity in the liver and other tissues, and altering secretion of gastrointestinal tract hormones that control nutrient metabolism.[2,3,6] The ability of dietary fiber to form a viscous gel and, thus, impair convective transfer of glucose to the absorptive surface of the intestine appears to be of greatest importance.[3] More-viscous soluble fibers are more effective in slowing glucose diffusion than less-viscous insoluble fibers. Improved control of glycemia with consumption of soluble fibers, compared with insoluble fibers, has been documented in diabetic humans.[1-3] Other investigators found both fiber types to be beneficial in diabetic humans[7,8] and dogs.[4,5]

To our knowledge, studies evaluating the effect of dietary fiber on control of glycemia in cats with naturally acquired diabetes mellitus have not been reported. The purpose of the study reported here was to determine the effect of dietary insoluble fiber on control of glycemia in cats with naturally acquired diabetes mellitus.

Materials and Methods

Cats—Twenty-five cats with naturally acquired diabetes mellitus were entered in the study. At the time of entry into the study, cats had been receiving treatment for 2 to 8 months, using the same amount of beef- and pork-source ultralente[a] (n = 15), lente[b] (9), or recombinant human-source lente[c] (1) insulin administered twice daily. A complete history, physical examination, CBC, serum biochemical analysis, determination of serum thyroxine concentration, and urinalysis were performed on each cat, and a **glucagon stimulation test (GST)** was performed in 18 cats at time of entry into the study. Results of the GST were used to assess residual β-cell function in each cat.[9] Insulin was not administered for 24 hours, and food was withheld for 12 hours before the GST. For the GST, samples for determination of serum insulin concentration were obtained before and 5, 10, 20, 30, and 60 minutes after IV administration of 0.5 mg of glucagon[d]/cat.[9]

Diets—The 2 diets used in the study (**Appendix**) were produced by a pet nutrition company[e] and designed to mimic commonly available commercial maintenance diets[f] and products high in insoluble fiber.[g,h] Canned diets were prepared from the same protein, fat, and carbohydrate sources. Additional ingredients, including vitamins and minerals, were added in identical amounts to make the diets nutrition-

ally complete and balanced for adult cats. Powdered cellulose[i] was added to one of the diets to increase the content of insoluble fiber to 12% (on a dry-matter basis) and create a **diet high in insoluble fiber (HF diet)**. Cornstarch, a digestible carbohydrate, was added to the other diet, creating a **diet low in insoluble fiber (LF diet)**, compared with the cellulose-supplemented diet. Analysis of fiber content of each diet was performed by an independent laboratory,[j] using the Furda enzymatic digestion technique with amylase, pepsin, glucosidase, and ethanol precipitation.

Experimental protocol—A crossover design was used, with cats randomly assigned to 1 of 2 diet sequences. Each cat was fed an assigned experimental diet for 24 weeks and then fed the other experimental diet for 24 weeks. One investigator (DJD) was aware of the diets fed to each cat during the study; the remaining investigators did not know the fiber content of the diets until completion of the study. Type and source of insulin and frequency of insulin administration (ie, twice daily) for each cat were the same as before the study and were maintained constant throughout the study. Insulin dosage was adjusted as needed on the basis of specific criteria; the same dosage of insulin was used for a specific cat for administration at 12-hour intervals. Initially, daily caloric intake of experimental diets was 60 kcal/kg (27.3 kcal/lb) of body weight. Daily caloric intake was divided into 2 equal-sized meals and fed at 12-hour intervals to coincide with the time of each insulin injection. Body weight was determined weekly by the owners, and daily caloric intake was adjusted as necessary to maintain each cat within 0.5 kg (1.1 lb) of its body weight at the time of entry into the study. Owners kept a logbook and recorded daily the amount of insulin injected, amount of diet fed, and signs of hypo- or hyperglycemia (ie, weakness, tremors, seizures, polyuria, polydipsia). Additionally, body weight was recorded weekly, and additional problems and treatments were recorded on the day of each event.

Control of glycemia was assessed immediately before (week 0) and 2, 4, 6, 12, 18, and 24 weeks after initiation of each 24-week feeding trial. In addition to reviewing the owner's logbook, assessment involved a complete physical examination, measurement of body weight, and evaluation of results of serum glucose concentrations measured every 2 hours for 12 hours beginning at the time of the morning insulin injection. Blood samples were obtained by repeated venipuncture. All cats tolerated the collection of blood samples; none of the cats became fractious during the study. Adjustments of insulin dosage were made as needed, with the intent to maintain most serum glucose concentrations between 100 and 300 mg/dl throughout the day. Insulin dosage was adjusted when clinical signs were unacceptable to owners or serum glucose concentrations were < 80 or > 300 mg/dl. An additional assessment of control of glycemia was performed 2 weeks after a change in insulin dosage and at the evaluation 6, 12, or 18 weeks after initiation of a diet.

Variables assessed in the study included results of CBC and serum biochemical analyses; plasma triglyceride, serum cholesterol, and serum glucose concentrations measured during the preprandial (ie, nonfed) state; blood glycated hemoglobin concentration; postprandial serum glucose concentrations; 12-hour mean serum glucose concentration; and mean fluctuation in serum glucose concentration from the 12-hour mean serum glucose concentration. All variables were assessed 6, 12, 18, and 24 weeks after initiation of each diet, except CBC and serum biochemical analyses, which were assessed at entry into the study and at week 24 after initiation of each diet. The 12-hour mean serum glucose concentration was the mean of 7 serum glucose concentration measurements for samples that were obtained during each 12-hour blood-collection period at weeks 6, 12, 18, and 24 after initiation of each diet. Mean of these four 12-hour mean serum glucose concentration values obtained during each diet trial was determined for each cat, and this mean value was used to calculate the 12-hour mean serum glucose concentration for each diet. The 12-hour mean serum glucose concentration for each diet was the mean of all mean values derived from the four 12-hour mean serum glucose concentrations determined for each cat. Similarly, fluctuation in serum glucose concentration from the 12-hour mean serum glucose concentration was the SD derived from calculating the 12-hour mean serum concentration of glucose at weeks 6, 12, 18, and 24 after initiation of each diet. The mean of the 4 SD values obtained during each diet trial was determined for each cat, and this average value was used to calculate the mean fluctuation in serum glucose concentration for each diet. Mean fluctuation in serum glucose concentration for each diet was the mean of all mean SD values derived from calculating the 12-hour mean serum glucose concentration for each cat.

Analytic methods—Values for serum biochemical analyses and serum cholesterol and plasma triglyceride concentrations were determined by use of a chemistry analyzer.[k] Serum glucose concentrations were determined by use of a glucose oxidase method.[l] Quantitative analysis of blood glycated hemoglobin concentration was performed, using affinity chromatography.[10,m] Serum insulin concentrations were determined, using a radioimmunoassay previously validated for use in cats.[11]

Statistical analyses—For each variable, the mean of the values obtained at weeks 6, 12, 18, and 24 of each diet trial was determined for each cat, and the mean of each variable for all cats in each diet trial was calculated from the mean value calculated for each cat. Variables derived from diet trials were analyzed by use of a repeated-measures ANOVA, using a 2 within-factor (diet, week) linear model that incorporated the crossover structure and accounted for the dependent nature of the observations. During analysis of GST results, the highest increment of serum insulin concentration that was greater than the serum insulin concentration measured immediately prior to glucagon administration was defined as the insulin peak response. Serum insulin concentrations less than the sensitivity of the radioimmunoassay (ie, < 5 μU/ml) were assigned an arbitrary value of 2.5 μU/ml (ie, one-half the sensitivity of the insulin radioimmunoassay). A value of $P < 0.05$ was considered significant. Statistical analyses were performed with statistical software.[n] Data were expressed as mean ± SD.

Results

Sixteen of 25 cats completed the study. Three cats died or were euthanatized during the study because of lymphoma (1 cat), chronic pancreatitis (1), and trauma resulting from being hit by a car (1); 3 cats were removed from the study, 2 because of acromegaly and 1 because of renal failure; and diabetes mellitus resolved in 3 recently diagnosed diabetic cats (6, 6, and 12 weeks after entering the study, respectively). At the time the diabetic condition resolved, 2 of these cats were being fed the LF diet, and the other cat was being fed the HF diet. These 3 cats remained euglycemic 6 weeks after discontinuation of insulin treatments and 6 weeks after changing from a LF to HF diet or from a HF to LF diet.

The 16 cats that completed the study comprised 11 domestic short- and longhaired, 3 Siamese, and 2 Himalayan cats. Twelve cats were castrated males, and 4 were spayed females. Cats ranged from 7 to 14 years old (mean, 9.8 years), and body weight ranged from 3.2 to 7.1 kg (7 to 15.6 lb; mean, 5.1 kg [11.2 lb]).

Abnormalities identified in the 16 cats during physical examination at the time of entry in the study included mild obesity (7 cats), hepatomegaly (3), detection of a small thyroid nodule (3), cardiac murmur (2), cardiac gallop rhythm (2), gingivitis (1), dry hair and hyperkeratosis (1), mild diffuse thickening of small intestine (1), and thin appearance (1). Abnormalities identified from results of CBC, serum biochemical analyses, and urinalysis performed at the time of entry into the study were consistent with diabetes mellitus and included hyperglycemia (16 cats; range, 219 to 531 mg/dl; mean, 406 mg/dl; reference range, 80 to 110 mg/dl), glycosuria (16), hypercholesterolemia (6; range, 168 to 399 mg/dl; mean, 282 mg/dl; reference range, 60 to 160 mg/dl), and an increase in serum alanine transaminase activity (1; 150 U/L; reference range, 28 to 106 U/L). Serum thyroxine concentrations were within the reference range, and results of tests for FeLV and feline immunodeficiency virus were negative in all cats. Baseline serum insulin concentration in 15 cats ranged from 2.5 to 10 μU/ml (mean, 6 ± 3 μU/ml; reference range, 5 to 20 μU/ml), and insulin peak response after IV administration of glucagon ranged from 1 to 4 μU/ml (mean, 2 ± 1 μU/ml; reference range,[9] 39 ± 34 μU/ml). In 1 cat, baseline serum insulin concentration was 24 μU/ml, and insulin peak response was 2 μU/ml.

Eight cats were fed the LF diet followed by the HF diet, and 8 cats were fed the HF diet followed by the LF diet. Cats did not become inappetent, but problems with palatability of the LF diet were reported by 4 owners. Periodically, these 4 cats would not eat initially after being given the LF diet or would not eat the entire meal. Four cats developed mild constipation when fed the HF diet. Five owners preferred to feed their cat the HF diet because of palatability, but 11 owners did not express a diet preference for their cat. Body weight was maintained throughout the study within 0.5 kg of each cat's weight at the time of entry into the study; mean body weight did not differ significantly between cats when consuming the HF diet, compared with the period when they were consuming the LF diet (**Table 1**). Although daily caloric intake was less when cats consumed the HF diet versus the LF diet, it was not significantly different.

Given their preexisting conditions, cats remained relatively healthy throughout the study, and owners usually were satisfied with results of treatment of their diabetic cats at each evaluation. Owners mentioned recurrence of polyuria-polydipsia at 4 and 8 evaluations when cats consumed the HF and LF diets, respectively. Disorders diagnosed during the period when cats were consuming the HF diet included flea-allergy dermatitis (4 cats), otitis externa (3), gingivitis (2), and cat-bite abscess (1). Disorders diagnosed during the period when cats were consuming the LF diet included gingivitis (4 cats), otitis externa (3), flea-allergy dermatitis (3), plantigrade stance (1), superficial pyoderma (1), skin lacerations of unknown cause (1), and diarrhea (1). Bacterial infections, diarrhea, lacerations, and plantigrade stance resolved with treatment, and flea-allergy dermatitis was controlled with appropriate treatment designed to avoid interfering with the efficacy of insulin treatment. Gingivitis was mild in affected cats and was not treated during the study. Glucocorticoid preparations were not administered to any of the cats for these disorders.

Results of CBC were within reference ranges in all cats throughout the study. Abnormalities frequently identified during serum biochemical analyses included hyperglycemia and hypercholesterolemia. Results for serum biochemical analyses were within reference ranges in all cats throughout the study, except that serum alanine transaminase activity was increased (112 and 467 U/L) in 2 cats at the end of the feeding period for the LF diet. Results for variables included in serum biochemical analyses did not differ between cats fed the 2 experimental diets, except for plasma triglyceride concentrations, which were significantly ($P < 0.01$) less when cats were fed the HF diet (63 ± 26 vs 79 ± 32 mg/dl). Although serum cholesterol concentration was less when cats were fed the HF diet (206 ± 94 mg/dl), compared with when cats were fed the LF diet (226 ± 97 mg/dl), the values were not significantly different.

Week of sample collection and a diet-week interaction did not significantly affect results of any variable

Table 1—Variables used to assess glycemic control in 16 cats with insulin-dependent diabetes mellitus fed a diet high in insoluble fiber (HF diet) and a diet low in insoluble fiber (LF diet)

	All cats		12 cats		4 cats	
Variables	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**
Body weight (kg)	5.3 ± 1.2	5.4 ± 1.2	5.5 ± 1.2	5.5 ± 1.0	4.7 ± 1.4	5.0 ± 1.6
Caloric intake (kcal/kg/24 h)	71 ± 20	62 ± 17	70 ± 21	62 ± 18	74 ± 18	64 ± 17
Insulin dosage (U/kg/24 h)*	1.5 ± 0.9	1.2 ± 0.6	1.5 ± 0.9	1.1 ± 0.6[c]	1.2 ± 0.6	0.9 ± 0.3
Preprandial mean serum glucose (mg/dl)	296 ± 98	215 ± 75[c]	335 ± 74	200 ± 62[a]	178 ± 57	260 ± 101
12-hour mean serum glucose (mg/dl)†	267 ± 81	195 ± 73[b]	293 ± 70	186 ± 72[a]	185 ± 55	223 ± 79
Mean fluctuation from 12-hour mean blood glucose concentration (mg/dl)‡	71 ± 23	62 ± 27	72 ± 24	60 ± 29	67 ± 24	69 ± 25
Glycated hemoglobin (%)	2.6 ± 0.5	2.1 ± 0.5	2.6 ± 0.5	2.1 ± 0.3[b]	2.3 ± 0.4	2.4 ± 0.8

Data represent mean ± SD of results obtained on weeks 6, 12, 18, and 24 for both diets for all 16 cats, for 12 of the 16 cats that had improvement in values of variables used to assess control of glycemia when they consumed the HF diet, and for 4 of the 16 cats that did not have improvement in values of variables used to assess control of glycemia when they consumed the HF diet.

*Insulin dose/24 h was divided equally and administered every 12 hours. †Values represent mean values calculated from serum concentrations of glucose measured at 2-hour intervals for 12 hours. ‡Values represent mean of the SD from the glucose mean calculated from serum concentration of glucose measured at 2-hour intervals for 12 hours.

[a-c]Values differ significantly ([a] = $P < 0.001$; [b] = $P < 0.01$; [c] = $P < 0.05$) between HF and LF diets.

To convert kilograms to pounds, multiply value by 2.2. To convert units per kilogram to units per pound, divide value by 2.2.

used to assess control of glycemia in this study. Similarly, diet did not significantly affect results for mean fluctuation in serum glucose concentration from the 12-hour mean serum glucose concentration. Independent of week of sample collection, diet significantly affected mean serum glucose concentration measured during the preprandial state and the 12-hour mean serum glucose concentration. Diet also affected, but not significantly, mean daily insulin dosage and mean glycated protein concentration. Mean serum concentration of glucose measured before the morning insulin injection and after withholding food for 12 hours was significantly less when cats consumed the HF diet, compared with when cats consumed the LF diet (Table 1). The subsequent mean serum concentration of glucose measured after the morning insulin injection was significantly lower at most sample collection times when cats consumed the HF diet, compared with when they consumed the LF diet (**Fig 1**). As a result, 12-hour mean serum glucose concentration was significantly ($P < 0.01$) less when cats consumed the HF diet, compared with when cats consumed the LF diet. Mean daily insulin dosage and mean glycated hemoglobin concentration also were less, but not significantly ($P = 0.05$ and 0.07, respectively), when cats consumed the HF diet, compared with the LF diet.

When variables used to assess control of glycemia were evaluated in each cat, 12 of 16 cats had a decrease in the values of variables used to assess glycemic control during consumption of the HF diet, compared with values during consumption of the LF diet. Conversely, only 4 cats had a decrease in the values for these same variables when they consumed the LF diet, compared with values for these variables when they consumed the HF diet (Table 1). Type and source of insulin and sequence in which they were fed the diets did not have apparent effects on differences among cats when diet was analyzed for effects on control of glycemia.

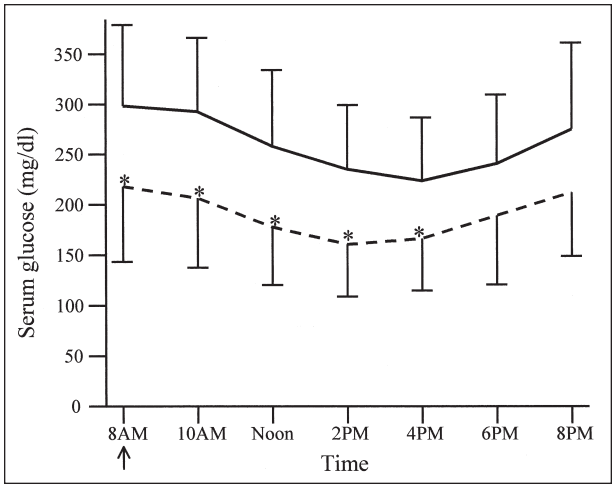

Figure 1—Mean (± SD) serum concentration of glucose in samples obtained from 16 cats with naturally acquired diabetes mellitus prior to feeding (preprandial [nonfed] state, 8 AM) and obtained for 12 hours after insulin administration and concurrent consumption of a meal high in insoluble fiber (HF diet; — — —) or low in fiber (LF diet; ———). Immediately after collection of the blood sample at 8 AM, a dose of insulin was administered (arrow), and cats were fed half of their daily caloric intake. Mean serum concentration of glucose is the mean of all corresponding serum glucose values obtained during the 12-hour blood sample-collection period for each cat at 6, 12, 18, and 24 weeks after initiation of each diet. *Values differ significantly ($P < 0.05$) from those for the LF diet.

Discussion

In the study reported here, consumption of a diet containing an increased amount of cellulose significantly decreased serum glucose concentrations in a group of 16 cats with naturally acquired diabetes mellitus, compared with glucose concentrations for those same cats when they consumed a LF diet. This decrease resulted despite similar mean body weight, daily caloric intake, and daily insulin dosage during the feeding periods for the HF and LF diets. When evaluated separately, 12 of 16 cats had significant decreases in serum glucose and blood glycated hemoglobin concentrations despite significantly lower mean daily insulin dosage with consumption of the HF diet, compared with values during consumption of the LF diet. Improvement in serum glucose concentrations was of sufficient magnitude to overcome variation in glycemic control attributable to differences in owner's daily routine and care of their pet as well as development of concurrent disorders commonly identified in older diabetic cats.[12]

Source of carbohydrate, sources and amounts of fat and protein, and percentage of metabolizable energy derived from fat and protein were similar in the 2 experimental diets. The crossover design of the study ensured that all cats were fed both diets, thereby minimizing inherent cat-to-cat variability. Analysis of results of the GST suggested that 15 of 16 cats did not have residual β-cell function at the beginning of the study,[9] and all cats that completed the study continued to require insulin injections to control blood glucose concentrations. Daily caloric intake or body weight did not differ significantly between the cats during consumption of each of the diets, and body weight was maintained in all cats. All investigators (except DJD) and owners were unaware of diet composition until completion of the study, thereby minimizing investigator and owner bias. Concurrent disorders commonly identified in older cats with diabetes mellitus[12] developed with approximately equal frequency during the feeding periods for the HF and LF diets and resolved or were controlled with appropriate treatment. Therefore, improvement in control of glycemia could be attributed to the composition of the cellulose-containing diet.

The greatest difference between the HF and LF diets was dietary fiber content, suggesting that the increased dietary fiber content of the HF diet played a role in improving control of glycemia. Proposed beneficial effects of fiber consumption include delaying gastric emptying, slowing carbohydrate absorption from the intestinal tract, augmenting insulin sensitivity in the liver and other tissues, and altering secretion of gastrointestinal tract hormones that control nutrient metabolism.[3,6,13] Ability of the dietary fiber to form a viscous gel and, thus, impair convective transfer of glucose and water to the absorptive surface of the intestine appears to be of greatest importance.[3] More-viscous soluble fibers slow glucose diffusion to a greater degree than less-viscous insoluble fibers and, as such, are believed to be of greater benefit in improving control of

glycemia in diabetic humans.[1-3] Others have found each fiber type to be beneficial in diabetic humans[7,8] and dogs.[4,5] Differences reported between the efficacy of soluble and insoluble fiber in improving diabetic control may be attributable, in part, to differences in type and quantity of fiber and other dietary ingredients, insulin treatment regimen used, existence and severity of diabetic complications, study duration, and client-patient compliance.[7,14,15]

Carbohydrate content was higher in the LF diet than the HF diet, on the basis of the difference between nitrogen-free extract and crude fiber as an estimate of carbohydrate content (Appendix). The higher carbohydrate content and metabolizable energy derived from carbohydrates of the LF diet, compared with the HF diet, may have contributed to differences in control of glycemia between the 2 diets. Adult cats efficiently utilize most carbohydrates added to the diet, including cornstarch.[16] However, activity of glucokinase and hexokinase in the liver is low in cats, compared with that for carnivores with omnivorous dietary habits (eg, dogs, rats).[17,18] Glucokinase and hexokinase enhance glucose uptake by the liver by catalyzing phosphorylation of glucose to glucose-6-phosphate in hepatocytes. Decreased activity of these enzymes may reduce the liver's capacity to handle a high-glucose meal in cats, compared with the capacity in other species, and may result in higher blood glucose concentrations, compared with concentrations for diets that have a lower glucose content. However, hepatic extraction of glucose in the prandial and postprandial periods may account for less than half of the total dietary glucose absorbed, suggesting that extrahepatic tissues play an important role in dietary glucose disposal.[19,20] Additionally, glucokinase is adaptive; feeding a high-carbohydrate diet should increase the activity of hepatic glucokinase and enhance dietary glucose uptake by the liver. Consumption of simple sugars (eg, glucose) has more effect on increasing blood glucose concentration than consumption of complex carbohydrates (eg, starch). To our knowledge, the effects attributable to varying dietary content of starch on blood glucose concentrations in cats have not been reported. It is not possible to determine effects that the differing carbohydrate content of the experimental diets had on glycemic control, other than to state that glycemic control was better with a HF diet and modestly lower carbohydrate content than for a LF diet and modestly higher carbohydrate content.

Daily insulin dosage and differences between owners regarding daily routine and care of their pet (eg, time of feeding and insulin administration, whether there were other pets or children in the house) were variables that could not be controlled in our study. The objective of our study was to maintain the best possible control of glycemia for each cat treated in its home environment, regardless of diet fed. Adjustments of insulin dosage are commonly used to control glycemia in response to influences, such as alterations in diet, exercise, or health. In this study, insulin dosage was adjusted as needed, determined on the basis of frequent reviews of clinical history and constant monitoring of results of physical examination, body weight, and blood glucose concentrations. The experimental design, in conjunction with the 6-week acclimation period at the beginning of each diet, is a major reason there were few, if any, differences in owner perceptions of response to treatment or physical examination findings between diets. Differences in objective data (ie, daily insulin dosage, serum glucose and glycated protein concentrations) were identified between diets; these differences can develop, despite normal results for clinical history and physical examination, when the majority of blood glucose concentrations are maintained between 100 and 300 mg/dl in diabetic cats.[21]

Palatability was not a problem with the HF diet. All cats consumed both diets and did not have difficulty maintaining body weight throughout the study. Four cats developed mild constipation when consuming the HF diet, but adjustments in the diet and addition of stool softeners were not required, and constipation resolved when the cats consumed the LF diet. Potential deleterious effects of high-fiber diets on binding or absorption of nutrients, especially trace minerals and fat-soluble vitamins, have been proposed,[22,23] although recent studies have not documented substantial adverse effects of chronic fiber intake on trace element and vitamin homeostasis in diabetic humans.[24,25] For the study reported here, we did not specifically evaluate this area, although clinical, hematologic, and biochemical abnormalities (aside from those caused by diabetes mellitus) were not found during consumption of the HF diet.

Serum cholesterol concentration measured in the preprandial state did not differ significantly between the periods when a cat was consuming each of the 2 experimental diets. Insoluble fiber may slightly reduce cholesterol absorption but does not consistently affect serum cholesterol concentration.[26,27] In contrast, plasma triglyceride concentration measured in the preprandial state was significantly lower when cats consumed the HF diet, compared with when cats consumed the LF diet. Differences in plasma triglyceride concentration may have been secondary to differences in diabetic control,[28] higher carbohydrate content of the LF diet,[15,29,30] or other unrecognized causes. Insoluble fiber alone does not have a consistent effect on serum triglyceride or very-low-density lipoprotein concentrations in humans, provided that caloric intake, type and amount of dietary fat, and cholesterol intake are unaltered.[26] Postprandial plasma triglyceride concentrations were not evaluated in our study, although in long-term studies in humans, postprandial plasma triglyceride concentrations do not appear to be influenced by high-fiber diets.[31]

When evaluated separately, consumption of the HF diet did not improve values for the variables used to assess control of glycemia in 4 of 16 cats. The reason for differences in response to the HF diet among cats is not readily apparent and may simply represent variability in response to cellulose-containing diets among cats; this variability has been identified in diabetic humans[2] and dogs.[5] Regardless, the study reported here documented substantial improvement in control of glycemia in 12 of 16 diabetic cats fed a diet designed to mimic commonly available products high in insoluble fiber, compared with control of glycemia in cats fed a

diet designed to mimic commonly available commercial maintenance products. Improvement was documented while the owners served as the primary caretakers and despite differences in owners' daily routine and care of their pet and development of concurrent disorders commonly associated with diabetes in cats. Results of this study support feeding commercially available diets containing approximately 12% insoluble fiber on a dry-matter basis to cats with naturally acquired diabetes mellitus.

[a]Iletin I Ultralente insulin, Eli Lilly Co, Indianapolis, Ind.
[b]Iletin I Lente insulin, Eli Lilly Co, Indianapolis, Ind.
[c]Humulin-U insulin, Eli Lilly Co, Indianapolis, Ind.
[d]USP Glucagon, Eli Lilly Co, Indianapolis, Ind.
[e]Hill's Pet Nutrition Inc, Topeka, Kan.
[f]Purina Cat Chow, Ralston Purina Co, St Louis, Mo.
[g]Hill's Prescription Diet Feline w/d, Hill's Pet Nutrition Inc, Topeka, Kan.
[h]Purina Clinical Nutrition Management OM-Formula Feline, Ralston Purina Co, St Louis, Mo.
[i]Solka Floc, Fiber Sales, Urbana, Ohio.
[j]Woodson-Tenent Laboratories Inc, Des Moines, Iowa.
[k]Cobas Mira Plus, Roche Diagnostics, Branchburg, NJ.
[l]Beckman glucose analyzer 2, Beckman Instruments Inc, Brea, Calif.
[m]Glyc-Affin GHb, Isolab Inc, Akron, Ohio.
[n]BMDP Professional, BMDP Statistical Software Inc, Los Angeles, Calif.

Appendix

Composition, metabolizable energy (ME), and fiber content of a diet high in insoluble fiber (HF diet) and a diet low in insoluble fiber (LF diet)

	HF diet*			LF diet*		
Components in diet	Composition (% DM)	ME† (%)	Fiber content (g/1,000 kcal of ME)	Composition (% DM)	ME (%)	Fiber content (g/1,000 kcal of ME)
Protein	44.6	48.0	NA	44.5	42.8	NA
Fat	8.7	22.7	NA	8.7	20.4	NA
NFE‡	27.2	29.3	NA	38.2	36.8	NA
Crude fiber	12.6	NA	38.6	1.8	NA	4.9
Total dietary fiber§	19.9	NA	61.2	4.1	NA	11.3
Total insoluble fiber§	19.0	NA	58.4	4.1	NA	11.3
Total soluble fiber§	0.9	NA	2.8	ND	NA	ND

*Diets were composed of water, beef by-products, liver, ground yellow corn, poultry by-product meal, glandular meal, vitamin and mineral supplements, and cellulose or cornstarch. †Percentage of total ME derived from protein, fat, and NFE. ‡Calculated by difference. This component of total dietary energy was then used to calculate ME, as defined by the Association of American Feed Control Officials. §As determined by Woodson-Tenent Laboratories Inc, Des Moines, Iowa, using the enzymatic-gravimetric method (Association of Official Analytical Chemists method 991.43, 1992).
DM = Dry matter. NFE = Nitrogen-free extract. NA = Not applicable. ND = Not detected.

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