CHAPTER

19

Current Controversies in Feline Nutrition

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OUTLINE

When thinking about feeding the domestic cats in your client's household, the veterinarian may need to make recommendations that are more involved than merely prescribing a certain amount of commercially available food for the specific life stage of each cat. Many clients are now taking matters into their own hands, sifting through information they find on the Internet, in books, on television, or by word of mouth, and making their own dietary decisions. How should the responsible veterinarian respond when owners say they plan to feed their cat a raw food diet or a homemade one based on a recipe they found online?

This chapter explores current controversial issues in feline nutrition. By the end of this section, the reader will be familiar with the most recent research and should be able to make confident, informed recommendations (at least until the next new diet fad appears).

RAW FOOD DIETS

Proponents of raw food diets have a very basic philosophy: Cats are obligate carnivores designed to eat raw meat similar to what their ancestors consumed. Traditional extruded and canned commercially available diets have been heat processed, which can degrade vitamins, minerals, and enzymes inherently contained in the preprocessed form. The ancestors of domestic cats were not affected by nutrient degradation because they hunted live prey and ingested meat from fresh carcasses. In addition to maintaining the natural nutrient balance, proponents also claim that these diets offer benefits such as improved immune function, general health, energy, coat and skin condition, and behavior. It has also been said that general body odors (breath, body, and feces) will be minimized and the incidence of various medical conditions reduced.[17]

Published in 1993, *Give Your Dog a Bone,* by Dr. Ian Billinghurst,[5] was one of the first widely publicized and referenced manuals on feeding raw diets. Dr. Billinghurst followed this with another book, *The BARF Diet: Raw Feeding for Dogs and Cats Using Evolutionary Principles,*[6] which catapulted raw food diets to an area of prominence in 2001. With this book Dr. Billinghurst provided an "introductory primer" to allow cat and dog owners to return their pets to "their evolutionary diet." He coined the acronym *BARF,* meaning either "biologically appropriate raw food" diet or "bone and raw food" diet. The basis of Dr. Billinghurst's diet plan is that a feline diet should mimic the carcass of a small mammal or bird and should contain 75% raw meaty bones, 15% crushed offal (internal organs), and 5% crushed vegetables and supplements to mimic feces and soil. Although individual meals can be balanced, Billinghurst contends that achieving nutrient balance over many meals is preferable.[6]

He may have been instrumental in starting the raw food evolution, but Dr. Billinghurst is not alone. A quick Internet search garners a wide variety of raw food producers and promoters. There are also many owner testimonials and other anecdotal reports claiming that raw diets improved animals' health problems, behavior, and appearance (to name a few). At the time of manuscript preparation there were no peer-reviewed research

publications with data in accordance with or in opposition to these reports. However, there are published data regarding concerns voiced by raw diet opponents, including the possibility of bacterial and nonbacterial contamination with zoonotic potential, nutritional inadequacies, and clinical diseases.

Contamination Concerns

Salmonella

Salmonella has gained the most attention regarding bacterial contamination concerns of raw food diets. In humans the national rate of reported *Salmonella* isolates in 2006 was 13.6 per 100,000 in the United States.[9] A large proportion of *Salmonella typhimurium* isolates, the most commonly isolated subtype, have also been found to be resistant to multiple antimicrobials. In 2004 39% of nationally reported *S. typhimurium* isolates in the United States were resistant to one or more drugs, and 23% had a five-drug resistance pattern.[10]

Symptoms of salmonellosis are similar across species and include fever, vomiting, abdominal pain, and diarrhea. Severe cases, especially in previously immunocompromised individuals or in individuals with systemic disease, can be fatal. It is common, however, for *Salmonella* to be present in the feces of asymptomatic animals. According to published estimates, 1% to 36% of healthy dogs and 1% to 18% of healthy cats are asymptomatic fecal shedders. Fecal shedding of *Salmonella* can wax and wane after the first week of infection, and clinical signs are seen in conjunction with stress and immunosuppression.[35]

Whereas most human *Salmonella* infections originate from food animals, food sources include eggs, meat, poultry, and produce. Human infections are also seen involving direct contact with animals and their environments.[8] It is the combined risk of using raw meat and poultry while in close contact with pets and their environments that has raw food opponents concerned for human safety.

There are multiple published reports of pet dogs and cats testing positive for *Salmonella* isolates that were indistinguishable from isolates obtained from humans. In these cases both symptomatic and asymptomatic animals were linked to humans in multiple capacities. Some were staff in veterinary clinics, individual pet owners, children of owners, or neighbors of infected pets. A connection was also found between children attending a day care center with a child living with two asymptomatic positive cats.[11,36,53] Only one of these reports mentioned diets consumed by *Salmonella*-positive pets. In this case a symptomatic infant was positive for a *Salmonella* Virchow isolate that was indistinguishable from isolates found in two of three asymptomatic dogs living in the same home. All three dogs were fed a commercial diet supplemented with boiled chicken 2 to 3 times per week.[36] *Salmonella* isolates in all of the previous reports were also resistant to multiple antimicrobials, with flouroquinolones and third-generation cephalosporins included in some cases. This is significant because these classes of antimicrobials are commonly used to treat human salmonellosis.[53]

Risk of zoonosis is an important consideration with salmonellosis, especially because in all the aforementioned reports, multiple pets in a household were infected with variation in the presence of symptomatic and asymptomatic pets.[11,36,53] After an investigation in one veterinary clinic, 5 of 43 hospitalized cats tested positive for *Salmonella,* including the asymptomatic blood donor cat. The floor of the boarding area and floor and door handles to the isolation ward in this clinic also tested positive.[53] In another veterinary clinic, three previously healthy pets developed transient diarrhea after prophylactic dental procedures performed by a veterinary technician later determined to be *Salmonella* positive. One of the three pets had a positive stool sample with an isolate indistinguishable from that of the veterinary technician.[11]

These reports underscore the importance of training veterinary staff to recognize, address, and learn to avoid situations that can place themselves and others at risk of *Salmonella* infection. On the basis of a list of factors contributing to four of the aforementioned outbreaks, pertinent reminders for all veterinary staff can be made (Box 19-1).[53]

One recommendation on the list involves environmental contamination concerns. A small study by Weese and Rousseau[50] evaluated survival of *Salmonella* spp. in pet food bowls using a *Salmonella* Copenhagen isolate previously obtained from a commercial raw food product. They inoculated multiple bowls and left them at room temperature for 7 days. The average concentration of *Salmonella* spp. was 5.4×10^5 colony-forming units per gram, and *Salmonella* was isolated from all bowls on days 1, 2, 4 and 7. They then took six stainless steel and six plastic food bowls and inoculated them with the

BOX 19-1

Reminders of *Salmonella* Risk in Veterinary Facilities

1. There is a risk of occupational zoonotic transmission of *Salmonella* spp.
2. There is a risk of zoonotic transmission of *Salmonella* spp. to clients and pet owners.
3. There is a risk of nosocomial transmission of *Salmonella* spp. among animals in veterinary facilities and animal shelters.
4. Environmental contamination can serve as an ongoing source of infection, especially when eating and drinking from contaminated work surfaces.

TABLE 19-1 Bacteria Types Recovered from 25 Commercial Raw Food Diets Purchased in Ontario, Canada

Bacterium type	Total result
Escherichia coli	16/25
Salmonella spp.	5/25
Campylobacter spp.	0/25
Spore-forming bacteria	4/25 (direct culture), 25/25 (enriched medium)
Clostridium perfringens	5/25
Clostridium difficile	1/25
Staphylococcus aureus	1/25

From Weese JS, Rousseau J, Arroyo L: Bacteriological evaluation of commercial canine and feline raw diets, *Can Vet J* 46:513, 2005.

same *Salmonella* strain. After assigning the bowls to various disinfectant treatment groups, the researchers evaluated them for *Salmonella* persistence. No significant difference was noted among disinfection methods for the plastic bowls. Scrubbing the stainless steel bowl with soap and then soaking it in bleach was significantly more effective than no cleaning, warm water rinse, and warm water rinse with scrubbing. None of the cleaning techniques used was able to eradicate all traces of bacteria, including use of a dishwasher. Some of this may have been due to the amount of organic debris used to inoculate the dishes, but the risk of food bowl contamination is an important concept to discuss with owners participating in raw feeding.

Other Pathogens

In addition to *Salmonella*, other bacterial species common in raw meat include *Campylobacter* spp., *Escherichia coli, Yersinia enterocolitica, Listeria monocytogenes, Clostridium perfringens, Staphylococcus aureus,* and *Bacillus cereus*.[24] In a study of raw food diets purchased in Ontario, Canada, coliforms were present in all 25 raw diets sampled, with a mean value of 8.9×10^5 colony-forming units per gram.[51] Table 19-1 illustrates the total number and types of bacteria isolated from these raw food diets, which contain enteropathogens of both animals and humans.

Another study evaluated bacterial and protozoal contamination of commercially available raw, dry, and canned dog food diets. Of 233 samples 153 (53%) were positive for non–type-specific *E. coli*, including dry and canned food varieties. *Salmonella enterica* was found in 17 of 233 (5.9%) samples from raw products, and 3 of 144 (2.1%) samples contained *Cryptosporidium* spp. in raw and canned products. Unfortunately, the design of this study did not allow for direct comparison of the degree of bacterial contamination in raw versus dry and canned diets.[42]

A third study compared two commercial raw diets and three homemade raw diets. *E. coli* O157:H7 was found in one of the homemade diets, whereas all three of the homemade diets were negative for *Salmonella* spp.[17] These data are especially troubling because *E. coli* O157:H7 is an important human pathogen causing hemorrhagic colitis in all ages and hemolytic–uremic syndrome in children and the elderly, with mortality rates between 3% and 5%. There is also no current recommended antimicrobial therapy in humans for this specific bacterial agent.[12]

Nutritional Inadequacies

As previously discussed, according to the recommendations for Dr. Billinghurst's BARF diet, nutritional balance should be achieved over the course of many meals rather than each meal being individually balanced.[6] Logistically, it is difficult to determine the complete nutritive value of a home-prepared diet over many days owing to the large amount of variability. There are, however, canine data regarding three raw diet meals (two for adults, one for a puppy) prepared at home by three owners and two commercially available raw preparations. The two adult homemade diets and both commercial diets were compared to nutrient standards for canine adult maintenance developed by the Association of American Feed Control Officials (AAFCO). One commercial diet and both adult home-cooked diets were low in calcium and phosphorus, with an unbalanced calcium:phosphorus ratio. The same home-prepared diets and the second commercial diet had high vitamin D levels. There were also inappropriate variations in zinc, iron, magnesium, and vitamin E noted in these diets. Using AAFCO standards for canine growth, all the puppy homemade diets and both commercial diets had nutrient imbalances, especially in relation to calcium, phosphorus, and vitamin D.[17]

While there are no similar data published for feline diets, these results suggest that home-prepared diets (whether raw or cooked) are unbalanced until evaluated by a veterinary nutritionist. Further discussion of unbalanced diets is included in the homemade diet section later in this chapter.

Clinical Disease Concerns

Animal

When nutritional inadequacies are present in a diet, clinical disease may be a consequence depending on the affected nutrients, the duration of feeding the deficient diet, and the life stage of the animal. One of the most commonly reported nutritionally related clinical diseases is osteodystrophy attributed to derangements of calcium, phosphorus, or vitamin D. Even though the incidence of such musculoskeletal diseases is reportedly low in cats,[49] it is not unheard of, and all owners of affected animals should be asked about the specific diet

being fed so that the likelihood of this etiology can be assessed. There are multiple case reports involving both suspected and definitively diagnosed cases of nutritional secondary hyperparathyroidism[19,45,46,52] and vitamin D–dependent rickets[18,38,43] manifested as bone abnormalities in domestic and wild cats. Although not all of these cases were specifically linked to raw diets, most of them involve animals fed unbalanced diets. Therefore, as previously explained, it is important to remember that any raw food diet (even those commercially obtained) should be considered unbalanced until evaluated by a veterinary nutritionist.

Arguably the most severe consequence to feeding a raw-prepared diet involves the risk of septicemic salmonellosis. A case report involving diagnosed septicemic salmonellosis in two cats originating in the same household recounted the diagnostics and results obtained. Both were fed a homemade raw beef diet. The first, a 14-year-old Exotic Shorthair, was presented deceased with a 1 week history of weight loss, soft stools, and anorexia. Histopathologic evidence of necrotizing hepatitis, chronic enteritis, and interstitial pneumonia was noted on necropsy, with *S. typhimurium* isolated from the lung, liver, spleen, and kidney. Nine months later, a 10-week-old Exotic Shorthair kitten from the same household was presented moribund with a history of possible respiratory obstruction. After euthanasia, gross evidence of reduced fat and muscle stores, serous nasal discharge, corneal opacity, and consolidated lungs was noted along with histopathologic signs of suppurative pneumonia and enteritis with villi erosion and blunting. *Bordetella bronchiseptica* was isolated from the lungs, and *Salmonella newport* was identified in the lung and small intestine. Samples of the raw beef fed to the kitten yielded *S. newport* and *Salmonella bardo* and *E. coli* among many other bacterial isolates.[40]

Human

The public health concerns associated with raw diets deal with possible human exposure to *Salmonella* spp. and *E. coli,* among other pathogens. Some raw food proponents believe that the risk of human bacteriosis such as salmonellosis is inconsequential because there are so few documented cases of direct transfer from raw-fed pets to their owners. For the average healthy adult who is aware of foodborne pathogen risk and prevention, the chance of salmonellosis may be low. It is important to remember, however, that unless the gastrointestinal signs are severe, this same average healthy adult is unlikely to submit fecal culture samples from themselves and their pets, and many veterinarians reserve use of fecal cultures to those animals with refractory diarrhea. In many of the case reports referenced in the preceding sections, regulatory health officials actively obtained diagnostic fecal cultures only after the diagnostic laboratory noticed an outbreak pattern between a small subset of human or animal samples.[11,36,53]

The Bottom Line

The veterinarian's educational efforts should be focused especially on those raw-fed pet households containing immunocompromised people (children, elderly, those with chronic diseases) because these are higher risk individuals more likely to become infected. Disinfection of contaminated kitchen work surfaces and food bowls should be of paramount importance. Clients should consider using dishwasher-safe dishes and implementing a bleach soak into the disinfection regimen. Proper handwashing should be performed after every animal interaction, especially just before food preparation and consumption. If cats in the household are known to jump on kitchen counters, all of those surfaces should be considered contaminated at all times and food (human or animal) should be prepared only on other work surfaces such as cutting boards.

At this point sufficient evidence does not exist to determine whether raw diets affect immune function, general health, energy, coat and skin condition, behavior, metabolic diseases, or fecal odor. Although anecdotal reports may seem convincing, clinically based peer-reviewed studies are necessary before any definitive conclusions can be drawn. Until that occurs, veterinarians are advised to instruct owners to cook all meat included in home-prepared diets.

CATS AND CARBOHYDRATES

Cats are obligate carnivores that have naturally evolved to maintain blood glucose in the face of a low carbohydrate intake. The classic example of a low-carbohydrate feline diet is the rat carcass, which is 55% protein, 38.1% fat, 9.1% carbohydrate, and 1.2% fiber on a dry matter basis.[54] Because cats are carnivores, the adaptation to a high-protein diet such as the rat carcass is necessary because adult cats require 2 to 3 times more protein than adult omnivores, and kittens require 1.5 times more protein than do young of noncarnivorous species.[31] Cats also have constant hepatic glucose production from amino acids (gluconeogenesis) and a delay in dietary carbohydrate use (low glucokinase activity).[25] The combination of the natural adaptation to a high-protein diet and delay in dietary carbohydrate use has shaped the recent argument that carbohydrates should make up a small fraction of the average domesticated cat's diet. The one caveat to keep in mind regarding this argument is that most carbohydrates in pet foods are composed of complex carbohydrates, not simple sugars, as is common in processed human foods.[22] This is an important distinction because diets high in sucrose and simple sugars are

TABLE 19-2 Percent Dry Matter (%DM) Macronutrient Composition of Various Diets in Referenced Studies

	Hoenig et al[21]		*Mazzaferro et al*[28]	*Thiess et al*[44]		*Michel et al*[30]		*Bennett et al*[4]*		*Backus et al*[3]				*Frank et al*[17]		*Verbrugghe et al*[47]		
	HC	HP	LC	HC	HF	HC	LC	MC, HFb	LC, LFb	LC	LMC	MHC	HC	HFb	HP	LP	LF	LC
Protein	31	48	49	37	50	39	63	46	42	47	41	36	33	42	57	19	32	30
Fat	18	17	36	15	30	10	20	19	24	40	24	12	4	17	24	12	8	13
Carbohydrate	43	26	7	40	13	44	16	30	14	4	27	45	56	24	8	19	16	4
Crude fiber	1	1	—	2	1	7	1	12	0.4	—	—	—	—	11	4	0.2	0.2	0.3

HC, High carbohydrate; *LMC,* low to moderate carbohydrate; *MC,* moderate carbohydrate; *MHC,* moderate to high carbohydrate; *LC,* low carbohydrate; *HP,* high protein; *HFb,* high fiber; *LFb,* low fiber; *HF,* high fat; *LF,* low fat.
Dashes (—) indicate information not provided in referenced study.
*Caloric density of diets was not provided in study so dry matter calculations were made with the assumption of a 4000 kcal ME/kg DM diet.

not efficiently metabolized in the cat, but complex carbohydrates used in processed pet foods can be fully metabolized.

Fate of Carbohydrates in the Cat

With a diet high in carbohydrates, blood glucose rises, causing an increase in insulin requirements. Lipoprotein lipase activity increases as more glucose enters adipose cells for conversion into fatty acids, with subsequent storage as fat. With a low-carbohydrate diet, blood glucose and insulin levels are lower and enzyme pathways are altered to conserve glucose, limit gluconeogenesis from amino acids (to conserve body proteins), and mobilize fats. There is higher fat and protein consumption, and higher protein levels are needed to support increased hepatic gluconeogenesis. The hepatic glucose production is responsible for a slow and steady rate of glucose being released into the bloodstream, maintaining a consistent glucose level.[21]

The aforementioned concept is the basis of the human Atkins diet, with the idea that low dietary carbohydrate will cause a shift in metabolic drive from glucose oxidation to fat metabolism as the primary energy source. This leads to a lower serum glucose and limited drive for insulin secretion from pancreas. Purported benefits of this low-carbohydrate, high-protein diet in people are appetite control, increased calorie loss by way of futile cycling and ketone loss, improved insulin sensitivity, shift from glucose oxidation and lipogenesis to lipolysis, and weight loss.[2]

Whether discussing the low-carbohydrate concept in cats or humans, it is important to keep in mind that fat, protein, or both must increase to account for the loss of energy that would have been provided by carbohydrates.[21] Several published reports (Table 19-2) have evaluated the implications of replacing a low-carbohydrate diet with one higher in fat. One of these studies found that during growth, fat deposition was 2.5 times greater when a high-fat diet was fed to mice, and fat deposition was lower in the high-carbohydrate group.[7] Another found that total fat deposition is much less when a high-carbohydrate diet is fed compared with a high-fat diet.[3] A third study evaluated healthy cats fed three dry diets: low-carbohydrate, high-protein diet versus high carbohydrate, high-fat diet versus high-carbohydrate, high-fiber diet. The low-carbohydrate, high-protein diet resulted in a lower postprandial serum glucose concentration over a short period of time (10 hours) compared with preprandial levels, but it also resulted in twice as much postprandial insulin as the high-carbohydrate, high-fiber diet over the same period. This effect may have been due to the low-carbohydrate, high-protein diet's higher fat content, which can lead to insulin resistance, or its higher arginine level, which also increases insulin in cats.[30]

The problem with a direct cross-correlation of the aforementioned studies is that the diets varied in more than just the protein, fat, and carbohydrate content in that they were formulated by different manufacturers with different base ingredients. Thiess and colleagues[44] studied isonitrogenous diets in healthy male cats to diminish unwanted variation between diets. A high-carbohydrate diet was compared with a high-fat diet (see Table 19-2), resulting in a slightly elongated glucose clearance and decreased acute insulin response to glucose administration. These results suggest diminished pancreatic insulin secretion, beta cell responsiveness to glucose, or both with a high-fat diet.[44] Backus and colleagues[3] also limited for unwanted variability between experimental diets. The researchers studied 24 cats before and after gonadectomy with *ad libitum* feeding of one of four diets differing in carbohydrate content (see Table 19-2). Any difference in carbohydrate content among the diets was replaced with fat, whereas the same protein level remained across all diets. Metabolizable energy (ME) intake and body weight increased in all groups after gonadectomy, especially in females. The highest-fat diet (64% ME)/lowest-carbohydrate diet combination was associated with weight gain and increased insulin concentration, potentially indicating a risk factor for insulin resistance and subsequent diabetes mellitus (DM).

It is possible that less insulin resistance will be seen when feeding a high-protein diet because of increased heat production. Hoenig and colleagues[21] noted increased heat production in lean cats consuming isocaloric amounts of a high-protein diet compared with those consuming a high-carbohydrate diet (see Table 19-2). A long-term study is necessary to investigate whether cats with the same caloric intake develop less obesity and show less insulin resistance when fed a high-protein diet compared with high-carbohydrate diet.

Canned Versus Dry Carbohydrates

Canned food typically contains fewer carbohydrates, but specific differences between outcomes of feeding canned carbohydrates versus dry carbohydrates have not been studied. Despite this lack of data, many veterinarians now recommend that cat owners feed canned diets exclusively in an effort to limit carbohydrate intake. Most domesticated cats are neutered, which, as previously discussed, is associated with decreased metabolic rate and increased food intake. In owner-based surveys, owners are more likely to provide cats with dry food *ad libitum* rather than feed a specific amount of food in discrete meals, as they would with canned food.[23] Some veterinarians have expressed the concern that dry food may be a risk factor for development of obesity and DM. A survey based study of 96 diabetic cats versus 192 matched controls showed indoor confinement and physical inactivity are risk factors for DM, not the proportion of dry food consumed.[39]

Clinical Disease Concerns

Obesity

Obesity is one of the most prevalent conditions affecting domestic cats worldwide, which has led to widespread interest in nutritional intervention to limit its occurrence. Epidemiologic data have suggested that high-fat, rather than high-carbohydrate, foods play a role in obesity.[37] Further data show that total energy intake affects weight change in cats, with high-fat diets promoting excessive calorie intake, not high-carbohydrate content.[22] Crossover research was conducted involving 12 lean and 16 obese neutered cats fed either a high-carbohydrate (38.1 g/100 g) or a high-protein (45.2 g/100 g) diet each for 4 months to maintain weight (see Table 19-2). After this 8-month period, obese cats remained on their current experimental diet and intake was decreased to obtain approximately 1.5% body weight loss weekly to return to original lean weight. When obese cats on the high-protein diet lost weight, it comprised more total fat than cats on high-carbohydrate diet, but both groups lost same total amount of weight. It was noted that obesity, not protein or carbohydrate level of the diet, led to severe insulin resistance and a marked decrease of glucose effectiveness. The authors calculated each kilogram increase in weight led to approximately 30% loss in insulin sensitivity and glucose effectiveness, which is instrumental in DM development.[20] In another study using 24 group-housed adult cats, high-carbohydrate versus low-carbohydrate diets from different manufacturers were fed (see Table 19-2). Body condition and energy intake, not type of diet, influenced weight, but the cats were group housed and individual energy intake was not assessed.[28]

As mentioned previously, it is difficult to make direct correlations between studies because of the variation in ingredients used and final macronutrient composition of the diets. The data do, however, shape an argument that the amount of calories fed is inherently more important in weight gain with potential predisposition to DM than the specific nutrient composition of the food.

Diabetes Mellitus

The goals of nutritional management of DM are to blunt postprandial hyperglycemia, control body weight, support altered nutrient needs, improve peripheral insulin sensitivity, avoid diabetic complications, coordinate peak nutrient uptake, and achieve diabetic remission when possible.[21] To achieve these goals, using the metabolic adaptations mentioned in the preceding section, it has been hypothesized that a low-carbohydrate diet (<10% to 20% dry matter) is best.[54] Multiple authors have reported improved glycemic control in healthy and diabetic cats fed low-carbohydrate (<15% dry matter) diets (see Table 19-2).[4,16,26] Weight control and subsequent improved insulin sensitivity are also critical to the success of low-carbohydrate food.[21]

Feeding a low-carbohydrate canned food to 18 diabetic cats with or without acarbose (an α-amylase inhibitor) resulted in declines of blood glucose and serum fructosamine levels along with exogenous insulin requirements. More than 60% of cats fed the low-carbohydrate food reverted to a nondiabetic state.[26] Low-carbohydrate versus high-fiber, high-carbohydrate diets were studied in 63 cats with naturally occuring DM. Within 4 months of diet change, approximately 68% of cats consuming low-carbohydrate diets and 41% of cats in the high-fiber group discontinued insulin, but none of the cats that had been diabetic for longer than 36 months reverted to a non–insulin-dependent state. The authors concluded that diabetic cats fed low-carbohydrate foods are three times more likely to discontinue insulin and revert to a nondiabetic state.[4] To the author's knowledge, there are currently no published studies showing a benefit to feeding less than 12% (dry matter) of dietary calories as carbohydrate, which is the level in the aforementioned study. It is also interesting to note the similarity of 9.1% dry matter to the carbohydrate content of the average rat carcass.

Both of the aforementioned studies used variations in carbohydrate and fat in their diet formulations. Because fat is known to increase insulin resistance and decrease glucose tolerance, Thiess and colleagues suggested that it is logical to replace carbohydrates with protein. Anecdotal evidence that a high-protein diet leads to improved glucose homeostasis and lowering of insulin requirements was not found, insofar as the diet had no effect on insulin sensitivity.[44] The research team did find that the high-protein group exhibited significantly higher heat production, which may have eventually led to decreased food intake. Further study into this subject is warranted before making such conclusions.

Diabetic ketoacidosis (DKA) can be a complication of uncontrolled DM. The production of β-hydroxybutyrate is favored in cats with increased fat metabolism. However, urine ketone sticks react only with acetoacetate and acetone, so a positive reaction is not seen until ketones increase significantly, as with uncontrolled DM. Low-carbohydrate food improves weight loss and increases blood ketone levels because these diets also invariably have a higher fat level. It is important to keep in mind that diet-mediated ketosis is minimal compared with poor diabetic regulation, meaning that a positive urine ketone stick should not be considered a result of a low-carbohydrate diet.[21]

Contraindications for Low-Carbohydrate Diets

Any condition requiring protein or fat restriction should be carefully considered before recommending low-carbohydrate diets. This includes renal disease, severe hepatic disease, hepatoencephalitis, and possibly pancreatitis. Diet recommendations for cats with pancreatitis are somewhat controversial, with some experts advising moderate protein, low-fat, high-carbohydrate diets and others calling for high-protein, high-fat, low-carbohydrate diets.[21]

Recent Research

Using three isoenergetic homemade diets (low-protein versus low-fat versus low-carbohydrate), effects on glucose and insulin response were evaluated. Every 3 weeks, nine lean cats were exposed to one of three diets in a Latin square design until all cats had consumed each diet. There was no difference in glucose levels among diets. Although all diets did exhibit a bimodal insulin peak, the second peak insulin was delayed with the low-carbohydrate diet (45% DM protein, 48% DM fat). If followed long-term, this diet may have led to an insulin-resistant state that could have produced beta cell exhaustion. The authors also suggest the effect of carbohydrate on insulin sensitivity might be a U-shaped response in which extremely low- and extremely high-carbohydrate levels cause diminished insulin sensitivity. It is possible that a long-term evaluation of both diet conditions would exhibit eventual beta cell exhaustion.[47]

Another recent thought-provoking study examined kittens fed diets differing only in carbohydrate and protein content while in utero and after weaning during growth. Although the difference was not significant, kittens fed the high-protein diet tended to have a higher total average physical activity level. This trend may be related to the high thermal effect of protein consumption in lean cats noted by Hoenig and coworkers. The kittens fed the high-protein diet also tended to have more lean body mass compared with the kittens receiving the high-carbohydrate diets, but there was no difference in body fat mass between groups at 8 months of age. The trends lend themselves to a conclusion that food intake had greater influence on body composition than dietary macronutrient composition.[48] It will be interesting to compare results from these cats as adults in the future. Will the high-carbohydrate group become more obese than the high-protein group, or will long-term follow-up dispel all of our current thoughts on cats and carbohydrates?

The Bottom Line

As of this writing, there is still not enough concrete evidence to mandate the ideal carbohydrate content of a domestic cat's diet. Although cats are obligate carnivores requiring meat-containing diets to provide all the essential dietary nutrients, they are also able to effectively metabolize complex carbohydrates. Certain metabolic conditions will necessitate limited protein or fat with an unavoidable increase in dietary carbohydrate. The burden is still on the veterinarian's shoulders to consider each individual patient and determine the ideal nutritional strategy depending on that patient's life stage and disease status.

At this point it should be possible to reach a consensus that total energy consumption and weight management are paramount for both prevention of DM and induction of diabetic remission along with overall health. Perhaps in the future, when more long-term studies are published, there will be a standard recommendation for macronutrient composition of the average healthy cat's diet. For now it seems wise for the veterinarian to focus on helping the cat achieve a lean body weight rather than concentrating on the carbohydrate content or on whether the food is coming from a can or bag.

HOMEMADE DIETS

Cat owners may want to prepare meals for their pets in their own home for several reasons that fall in the following general categories:

1. Wariness regarding additives, preservatives, and contaminants
2. An inability to understand pet food label ingredients and subsequent distrust
3. A lack of suitable commercial products that meet the medical needs of the pet[33]

Many such owners also refer to their pets as their children, and they see an obligation to provide the best care possible, just as they would for a human child.

In a telephone-based survey in the United States and Australia, it was found that 13.1% of cats were fed non-commercial food such as table scraps, leftovers, and homemade diets as part of the main diet, and at least one quarter of the total diet for 6.2% of cats. The same survey also found 98.8% of cats were fed at least half their daily intake in the form of a commercial diet and were more likely to be fed *ad libitum* compared with dogs.[23] A separate report using the same telephone survey data noted that owners who fed their pets 50% to 75% home-prepared foods reflected greater mistrust of commercial pet foods, food processing, and the pet food industry and had more positive opinions about raw and home-prepared diets.[29]

Safety

In general, the most common safety concern voiced by owners unwilling to use a commercially available pet food product is the risk of contamination necessitating a diet recall, as occurred with the melamine contamination scare of 2007. From March 2009 through March 2010, the Food and Drug Administration (FDA) Center for Veterinary Medicine listed 10 reports of national pet food recalls. The reasons for these recalls ranged from possible *Salmonella* contamination of a nationally available raw food product to thiamine deficiency.[15] In the month of March 2010, there were more than 45 recalls of human food products with *Salmonella* contamination listed as a common inciting cause.[14] These statistics emphasize the point that all nationally produced food, whether for human or animal consumption, is closely scrutinized for contamination and safety of ingredients and that humans are much more likely to encounter a recall with a food item intended for their own consumption rather than one for their pet's consumption.

Other safety concerns owners have voiced regarding commercial diets include the use of artificial additives, especially preservatives, colorings, and flavorings, leading to long-term intake of these items.[27] Many fear that food additives play a role in carcinogenesis and development of dietary hypersensitivity or autoimmune disorders.[13] When evaluating the safety of a substance and whether it should be approved, the FDA considers the following factors:

- The composition and properties of the substance
- The amount that would typically be consumed
- The immediate and long-term health effects
- Various safety factors

All substances are approved in conjunction with an appropriate level of use that is much lower than what would be expected to produce an adverse effect.[32] Adverse events with a suspected association to specific food additives are reported to the FDA for investigation, allowing for ongoing safety reviews even after initial ingredient approval.

Despite this regulation process, foods free of artificial additives or with ingredients that are perceived to be more wholesome and safe can be appealing to the home-made diet enthusiast.[27] Even those looking for a more natural commercial diet must be educated about the regulations involving labeling of specific commercial diets. According to the AAFCO definition, a natural product is one in which all ingredients are derived solely from plant, animal, or mined sources that were not subjected to a chemically synthetic process and not containing any additives or processing aids that are chemically synthetic. Organic products must be produced and handled in compliance with requirements of the U.S. Department of Agriculture National Organic Program.[1] All commercial pet foods with labeling using the words *natural* or *organic* must meet the preceding definition.

From a public health standpoint, the most important documented safety concern related to use of homemade diets is the increasing popularity of raw food diets. There are also a growing number of commercially available raw food products. These feeding plans were discussed in preceding sections.

Complete and Balanced

All commercially available diets in the United States that are designed for long-term feeding must contain an AAFCO nutritional adequacy label on the packaging. This label will state that the diet either has been formulated to meet the needs of the specific life stage of the animal or has gone through an AAFCO feeding trial.[1] Homemade diet formulations are not governed by AAFCO regulation, and there is currently no standardized system in place regulating the nutritional adequacy of published home-prepared diet recipes. This lack of standardized regulation leads to concerns regarding the nutritional adequacy of homemade diets. Even if the diet is developed by a veterinary nutritionist, that diet is only as good as the database the nutritionist uses for individual ingredient evaluation, how well the client follows the instructions, and if the client deviates from the diet by substituting other ingredients over time.[33]

In a report analyzing 49 maintenance and 36 growth diets from six publications (compared with

AAFCO recommendations), 55% of the diets contained inadequate amounts of protein and 62% were inadequate in vitamins. Taurine or choline supplementation would have resolved the deficiency for 77% of the cases. Many of the ingredients in the databases used for ingredient nutrient levels are not analyzed for taurine and choline, meaning that diets determined as inadequate or deficient may have actually been adequate. Of these diets 86% were inadequate in various minerals and 8% were inadequate in essential amino acids.[34] In a separate study 44 commercial versus 35 home-prepared canine diets were compared. The diets were not different in energy content, but vitamin and mineral differences were noted. Home-prepared diet calcium to phosphorus ratios, vitamin A and E levels, along with potassium, copper, and zinc quantities were below AAFCO recommendations, whereas all commercial diet nutrients were above AAFCO minimums, except the calcium to phosphorus ratio, which was within the recommended range.[41]

Excessive protein is common in home-cooked diets, with many recipes recommending a ratio of greater than 1 part meat to 1 part grain. Excessively high protein levels can lead to a calcium imbalance with high phosphorus levels. Addition of bone, bone meal, or calcium does not resolve the calcium to phosphorus ratio issue of a diet that is also disproportionately high in phosphorus. Owners must also be educated that the vast majority of over-the-counter pet supplements do not contain vitamins and minerals in sufficient concentrations to balance and complete a homemade diet.[33] For all these reasons, homemade diets must be evaluated by a veterinary nutritionist to determine the risk or merit of feeding each individual diet.

The Bottom Line

For owners who have a strong desire to cook food for their pets at home, education is the major obligation of their veterinarian. There is currently no supportive information in the literature for safety concerns associated with FDA-approved food additives in the levels allowed in diets. Although occasional issues such as the widespread recall initiated by melamine contamination in 2007 do occur, they are rare in pet foods, especially compared with recalls of human food items.

There is minimal inherent risk of an owner feeding a homemade diet that is formulated by a veterinary nutritionist as long as the owner is diligent in following all specific ingredient and supplementation instructions. Many veterinary nutritionists are available for phone consultation and are able to analyze individual diets for nutritional adequacy. This will help to take this complicated burden off the shoulders of general practitioners while giving the owners access to accurate nutrition information.

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