Feeding Patients that have Chronic Kidney Disease: The Controversy and Lessons from the Literature

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Nutritional assessment of patients with chronic kidney disease
A complete nutritional assessment and staging of a patient’s chronic kidney disease (CKD) is required prior to making nutritional recommendations. The World Small Animal Veterinary Associations has guidelines to complete a nutrition assessment.1 Guidelines for staging and sub-staging recommendations are provided by the International Renal Interest Society (IRIS).2 When taking a diet and general history, the owner of a patient with CKD should be questioned about appetite, weight loss and time frame for weight loss, current diet, evaluation of current protein intake, treats or table foods, foods used for medication administration, and supplements. Evaluation of the patient should include body weight, body condition score (BCS), evaluation of muscle mass, and systolic blood pressure. Important laboratory parameters include creatinine, blood urea nitrogen (BUN), potassium, albumin, bicarbonate, urine specific gravity, and urine protein-to-creatinine ratio.

Adult maintenance diets versus therapeutic kidney diets
Kidney diets are amongst the oldest therapeutic diets for dogs and cats. The IRIS recommends nutritional intervention at IRIS stage 2 to control serum phosphate levels, however a diet change may be recommended for patients with IRIS stage 1 following a complete nutritional assessment. Double-blinded, randomized, controlled clinical trials have compared the efficacy of therapeutic kidney diets (TKD) to adult maintenance diets (AMD) in patients with ≥ IRIS stage 2 chronic kidney disease (CKD):

- Ross et al. fed cats with spontaneous IRIS 2 and 3 CKD a TKD (n = 22) or an AMD (n = 23) for 24 months.3 No cats in the TKD group experienced a uremic crisis and no kidney-related deaths occurred. Twenty six percent of cats in the AMD group had a uremic crisis and 21.7% of cats experienced a kidney-related death.
- Elliott et al. fed client-owned cats with spontaneous CKD a TKD (n = 29) or an AMD (n = 21).4 Cats fed a TKD had a median survival time of 633 days (1.7 years) compared to 264 days (0.7 years) for cats fed an AMD. Feeding a TKD also helped reduce plasma phosphate, blood urea nitrogen, and parathyroid hormone concentrations.
- Jacob et al. fed dogs with ≥ IRIS stage 2 CKD a TKD (n = 21) or an AMD (n = 17) for 24 months.5 Dogs fed a TKD has a median time to uremic crisis of 615 days and median survival time of 594 days. Dogs fed an AMD had a median time to uremic crisis of 252 days and median survival time of 188 days. Kidney related deaths accounted for 33% and 65% of deaths in the TKD and AMD groups, respectively.

These studies demonstrate that TKDs can be used to improve quality of life by controlling signs of uremia and increasing life span by altering disease progression.

Protein intake and chronic kidney disease
Protein restriction is commonly recommended for the management of CKD to reduce nitrogenous wastes and glomerular proteinuria. The timing and necessity of protein restriction to avoid protein malnutrition and loss of lean body mass (LBM) is controversial. Nitrogenous wastes can contribute to clinical signs associated with uremia, polyuria, polydipsia, and anemia. Loss of LBM related to chronic illness, also referred to as cachexia, occurs in patients with CKD. Cachexia is associated with altered strength, immune function, wound healing, and overall survival although more specific research in cats and dogs is needed.6 Dogs with a body condition score (BCS) of 1 – 3/9 had a reduced survival compared to dogs with a BCS of 4/9.7 The optimal protein intake for patients with CKD is likely multifactorial depending on the stage, sub-stage, and complete nutritional assessment of the patient.

Protein requirements
Protein requirements for dogs and cats have traditionally been determined through the use of nitrogen balanced studies, wherein nitrogen loss is equivalent to nitrogen intake. More recently, a study by Laflamme & Hannah evaluated the protein requirement of healthy adult male cats based on the maintenance of LBM.8 To achieve nitrogen balance, 56g protein/1000kcal of diet was needed while 95g protein/1000kcal was needed to maintain LBM. Regression analysis suggested that while 1.5g protein/kg body weight was required for nitrogen balance, 5.2 grams of protein/kg body weight is recommended to maintain LBM. This demonstrates that nitrogen balance can be achieved on a low protein diet, but it may be at the expense of LBM through the use of endogenous proteins. Suboptimal protein intake in the face of CKD can increase the production of uremic toxins through protein catabolism. It should be noted however that suboptimal protein intake can also result from hyporexia or anorexia which occurs commonly in patients with CKD.

Proteinuria and protein restriction
The American College of Veterinary Internal Medicine recommends a reduced protein intake in dogs with proteinuria secondary to glomerular disease.9 In rats and humans, protein directly injures the tubulointerstitium through release of vasoactive and inflammatory substances that trigger renal scarring and loss of function.10 Feeding a TKD may improve proteinuria.
• In dogs with hereditary nephritis, feeding a protein restricted TKD reduced structural damage to glomeruli by decreasing glomerular basement splitting and delayed the progression of kidney failure.11
• Dogs with proteinuria treated with benazepril fed a TKD had a reduced urine protein to creatinine ratio (UPC) over 60 days (UPC 3.16 to 1.2) compared to dogs fed an AMD (UPC 3.62 to 2.14).12 The dose of benazepril did not differ between groups.
• Proteinuria was reduced significantly in dogs with glomerulonephropathy when they were switched from a diet containing 72g protein/1000kcal to a diet containing 33g protein/1000kcal.13

A reduction in protein intake by 25 – 50% is recommended based on the severity of proteinuria and patient assessment. This reduction may be relative to the patient’s current intake.

Dietary protein in TKDs
At this time, there is no definitive conclusion in the veterinary literature of which is better: a diet with unrestricted protein with the remaining features of a TKD versus a protein restricted TKD. The answer to this question is likely dependent on the species, IRIS stage and sub-stage. Studies demonstrating improved survival of dogs and cats fed a TKD compared to an AMD are limited to those with confounding dietary variables such as phosphorus restriction. The amount of protein needed to achieve protein restriction is not clearly defined.
• National Research Council (NRC) Minimum Requirement for crude protein is 40 grams and 20 grams of protein per 1000kcal for cats and dogs, respectively
• Association of American Feed Control Officials (AAFCO) minimum crude protein is 65 grams and 45 grams of protein per 1000kcal for cats and dogs, respectively

At this time, TKDs for CKD range from 25 – 55 grams protein in dogs and 58 – 82 grams protein per 1000kcal in cats. A highly digestible protein source is recommended. Reduced protein digestibility is reported to occur in some geriatric cats.14

Phosphorus restriction
Phosphorus restriction, independent of other dietary factors, delays progression of CKD in both dogs and cats. Dogs with induced CKD fed a high phosphorus diet had significantly lower glomerular filtration rates and decreased survival compared to dogs fed a phosphorus restricted diet.13 Cats with induced CKD fed a normal phosphorus diet had evidence of renal mineralization, fibrosis and mononuclear cell infiltrates compared to cats fed a low phosphorus diet which has no histologic changes.16 AMDs often contain added phosphorus (usually >1.5g per 1000kcal) to avoid phosphorus deficiency and maintain a 1:1 – 2:1 calcium to phosphorus ratio. AAFCO minimum for adult cats is 1.25g/1000kcal and adult dogs 1g/1000kcal. TKDs range from 0.4 – 1.2 g/1000kcal and 0.8 – 1.35 g/1000kcal for dogs and cats, respectively.

Omega-3 fatty acids
Supplementation with polyunsaturated omega-3 fatty acids (EPA and DHA) can have renoprotective effects. Dogs fed a diet supplemented with a high dose of fish oil had reduced proteinuria, creatinine, and histopathologic lesions compared to dogs fed a diet supplemented with safflower oil or beef tallow.17 A standard dose of 40mg/kg EPA + 25 mg/kg DHA once daily is recommended for both cats and dogs. Recently, a specific dose for dogs with CKD was recommended: 140 mg EPA + DHA / (kg body weight)0.75.18 Some companies may add alpha-linoleic acid to TKDs, however this omega-3 fatty acid is insufficiently converted to EPA and DHA in both cats and dogs. Additional supplementation with EPA and DHA is recommended if the diet does not provide these nutrients.

Dietary potassium
Hypokalemia is common in cats with CKD and therapeutic diets may provide supplemental potassium beyond that added to a typical AMD. While hyperkalemia is typically associated with acute kidney failure, it may be a complication in some dogs with CKD. Hyperkalemia has been corrected by feeding a home prepared diet with reduced potassium (0.91 ± 0.14 g/1000kcal) in some dogs with CKD.19 Some TKDs contain potassium levels around this concentration which may be useful in these patients. Referral to a board-certified veterinary nutritionists for a home-prepared diet formulation may also be considered for a potassium restricted diet.

Other dietary features of TKDs
• Reduced sodium content to avoid the potential for sodium retention and contribution to systemic arterial hypertension
• Calorie dense with moderate to high levels of dietary fat to increase caloric intake and enhance palatability
• Alkalining to help correct metabolic acidosis
• Added antioxidants such as vitamin C and E to decrease oxidative stress
• Added soluble fiber to promote colonic bacterial growth and utilization of nitrogen and urea; beneficial for constipation
Tips for feeding patients with CKD

Introduce a TKD before clinical signs of uremia occur if possible. Diets are available in a variety of forms, flavors and textures. Provide clients with various samples to establish patient preferences. Be cautious when introducing a TKD to a hospitalized patient. This may lead to a food aversion in a diet best utilized for long-term feeding.

Feeding tubes are useful when managing patients with CKD. Liquid enteral diets containing < 1.5g phosphorus/1000kcal (both human and veterinary) are available for use with nasogastric and nasoesophageal feeding tubes. When an esophageal or gastric feeding tube is in place, a slurry of a canned TKD is recommended. Caloric density of a slurry can be improved when using a liquid enteral diet rather than water.

Home prepared diets are useful in patients with a poor or selective appetite. Referral to a board certified veterinary nutritionist is recommended. Home prepared diets found in books and on websites have numerous inadequacies and are not recommended. Before referral, updated IRIS staging including systolic blood pressure and UPC is recommended.

Overall, nutritional intervention in a cat or dog with CKD can greatly affect patient morbidity and mortality. The optimal diet for a patient with CKD relies on a variety of factors including the stage and sub-stage of disease, nutritional assessment, and patient preferences.

References
Obesity and (Pick Your Disease!): Managing Obesity and Concurrent Disease in Pets

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Obesity is the most common form of malnutrition in cats and dogs. Animals are considered obese when they reach a body condition score (BCS) of 8/9 which is approximately 20% over their ideal body weight or ≥35% body fat. Owners and veterinarians must both recognize that a patient is overweight or obese while also acknowledging the health consequences of excess adiposity. Surveys of dogs and cats presenting to veterinarians in primary or referral practices indicated that only 11.4% of overweight/obese dogs and 3.6% overweight/obese cats had overweight or obesity listed as a medical problem. Further, 53% of owners in one study assigned their overweight or obese dog with an appropriate BCS, however 39% of these owners thought their dog’s weight was acceptable or normal.

Life span and quality of life

Overweight/obesity significantly impact life span, quality of life, and the development of chronic diseases in cats and dogs. Labrador retrievers fed 25% less than age-matched pairs had a median life span of 13 years while dogs fed 25% more had a median life span of 11.2 years. Dogs fed more were overweight, not obese, with a mean BCS of 6.7±0.19 compared to the feed restricted dogs with a mean BCS 4.6±0.19. Chronic treatment for osteoarthritis was delayed in the feed restricted group (13.3 vs 10.3 years) and treatment for chronic diseases in general was also delayed (12 vs 9.9 years). Radiographic evidence of osteoarthritis (OA) was also found later in the feed restricted dogs (at 2 years of age, hip OA 4%/versus 42%). A similar life time study does not exists at this time in cats.

Mobility is often a factor for owners when assessing their pet’s quality of life. Modest weight loss of 6.1% significantly decreased lameness in dogs. Obese cats are 4.9 times more likely to develop lameness requiring veterinary care. Dogs completing a weight loss plan had improved quality of life (increased vitality and decreased emotional disturbance and pain) when compared to dogs that failed to achieve their ideal body weight. Cats undergoing weight loss for 8 weeks had an increase in pre-feeding behaviors such as begging, following, meowing, pacing however owner reported their cats became more affectionate post feeding.

Obesity paradox

The finding that overweight or obesity may be protective in regards to mortality in a variety of disease conditions is termed the obesity paradox. While overweight, obesity, and abdominal adiposity are associated with increased risk of heart failure in people, overweight/obesity are associated with lower all-cause and cardiovascular mortality in people with congestive heart failure (CHF). While the protective mechanism of the obesity paradox is not clear and likely multifactorial, increased reserve of lean body mass (LBM) with obesity and lack of cachexia likely plays a major role. Few studies investigate this phenomenon in veterinary medicine. In a recent abstract, cats below a median body weight of 4.2kgs at the time of diagnosis for chronic kidney disease (CKD) has a significantly shorter survival time compared to cats with a body weight ≥4.2kgs. Underweight dogs with CKD (BCS 1-3/9) had a significantly shorter median survival time (MST) compared to moderate (BCS 4-6/9) and overweight dogs (BCS 7-9/9) with no difference between moderate and overweight. A study of survival in dogs with CHF failed to demonstrate a significant association with BCS, however weight change was significantly associated with survival with dogs gaining weight surviving the longest. A similar study in cats with CHF found a U-shaped relationship between body weight and survival with reduced survival times in cats with the lowest and highest body weights. Given the available literature, maintenance of a BCS of 6-7/9 in patients with chronic diseases such as CHF or CKD is a reasonable recommendation to preserve LBM and prevent cachexia. Additional research is required to investigate this recommendation.

Chronic kidney disease

Obesity is a risk factor for the development and progression of CKD in people. Experimentally-induced obesity in dogs has been shown to increase mean arterial pressure and plasma renin activity, alter renal function (glomerular hyperfiltration), and cause histologic changes including expansion of Bowman’s capsule, increased mesangial matrix, thickening of glomerular and tubular basement membranes, and increased cell proliferation in the glomerulus. Following weight loss, dogs had evidence of improved renal function with increased urine specific gravity (USG), decreased urine protein to creatinine ratio (UPC), and decreased levels of biomarkers of renal injury (homocysteine, cystatin, and clusterin). Creatinine was also decreased after weight loss, but this may be confounded by the loss of LBM in addition to fat mass. In this same study, 8 dogs had UPC > 0.5 prior to weight loss, while only 1 dog had UPC > 0.5 after weight loss. Another study comparing UPC in dogs with BCS 4-5/9 versus ≥6/9 found no statistical difference between groups. The researchers in this study were unable to separate out overweight versus obese dogs for additional statistical analysis due to the limited sample size. Overweight/obese dogs and cats with CKD must be assessed on an individual basis.
to achieve optimal body weight. Generally the use of a therapeutic kidney diet will take precedence in dogs and cats with later stage CKD. In obese dogs and cats with early stage CKD (IRIS stage 1 ± 2), a weight loss plan may be considered only after a complete nutritional assessment and only if close monitoring is available. If progression of CKD is noted, active weight loss should be suspended and appropriate diet modifications should occur until further evaluation. Consultation with a board-certified veterinary nutritionists is recommended for obese patients with CKD.

Cancer

In people, increased body-mass index is associated with an increased risk of development and death from cancers including esophageal, thyroid, colon, kidney, endometrium, gallbladder, breast, and pancreas as well as development of leukemia, multiple myeloma, and non-Hodgkin lymphoma. Limited studies are available in veterinary medicine investigating overweight/obesity with cancer risk and outcomes. Some work suggests an increased risk in the development of mammary cancer and transitional cell carcinoma in dogs. In one study, the prevalence of overweight/obesity was slightly lower in dogs with cancer, although there was a higher prevalence of overweight/obesity in dogs with mammary cancers though this was not statically significant. Out of 100 dogs presenting to an oncology service at a veterinary teaching hospital, 26 were overweight and 29 obese based on BCS. Fewer data is available in cats with one study evaluating BCS and survival time finding feline cancer patients with a BCS <5 having a MST of 3.3 months compared to 16.7 months in cats with a BCS ≥ 5.

Before instituting a weight loss plan for an overweight/obese cancer patient, a complete nutritional assessment including cancer staging, evaluation of clinical signs, and determination of prognosis must be performed. Clinicians must decide if weight loss will provide a clinical benefit in light of the patient’s survival time. Weight loss to improve quality of life rather than achievement of ideal body weight may be appropriate for some animals such as an obese dog with osteosarcoma and OA now ambulating on 3 legs or an obese cat with lymphoma and diabetes mellitus receiving corticosteroids. Typically the author starts with a conservative caloric restriction to achieve slow rate of weight loss (0.5-1% body weight per week). Aggressive caloric restriction in a sick animal may contribute to preferential loss of LBM therefore serial assessment of muscle condition is also recommended. A high protein, high fat, and low carbohydrate diet is typically advocated in veterinary cancer patients to support LBM and protein metabolism as well as decrease the energy supply to neoplastic cells that are inefficient in oxidizing fat for energy. A diet with the above characteristics enriched in omega-3 fatty acids has been shown to prolong survival time is a subset of dogs with lymphoma compared to a similar diet unenriched in omega-3 fatty acids. Additional work is needed to investigate potential clinical benefits of high fat versus low fat diets in dogs and cats with cancer. Weight loss diets for dogs are generally low in fat to avoid increases in caloric density, but high in protein to support LBM. Some weight loss diets are formulated with higher amounts of omega-3 fatty acids which may be desired for reasons other than neoplasia including OA.

Diabetes mellitus

Diabetes mellitus (DM) in dogs is due to inadequate insulin production from immune-mediated destruction of beta cells or from pancreatitis. Feline DM occurs commonly due to peripheral insulin resistance as a result of excess adiposity and beta cell dysfunction. Although insulin resistance in dogs does exist, dogs will have an absolute requirement for insulin administration that diet alone will not correct. Insulin sensitivity in lean dogs was 58% greater than overweight dogs. Dogs with a body weight gain of approximately 43% had significantly higher basal insulinemia and insulin resistance. In contrast, cats can have insulin resistance at 10% over their lean body weight. Obese cats are up to 3.9 x as likely to have DM than cats with an ideal BCS. In dogs, the role of obesity in the development of DM is less clear although a relationship likely exists. Twenty percent of obese dogs in one study had criteria for obesity-related metabolic dysfunction. This criteria was modeled from human guidelines for diagnosis of metabolic syndrome, a risk factor in people for the development of Type II DM and cardiovascular disease. The progression of insulin resistance to the development of DM in dogs is not documented and further studies are needed to determine what these criteria in dogs mean for disease risk and outcomes.

Goals for managing an obese diabetic patient include eliminating clinical signs associated with hyperglycemia and glycosuria, avoiding hypoglycemia, improving patient body weight and condition, and maintaining the pet and owner’s quality of life. Initial recommendations for overweight and obese dogs should be weight maintenance until glycemic control is achieved. Once this is established, conservative weight management (0.5-1% body weight per week) can be instituted which may help to improve insulin sensitivity. A modest reduction in energy intake (decreasing caloric intake by 20%) with control of treat consumption (≤ 10% caloric intake) can be tried initially. Some dogs may require more or less caloric restriction for weight loss at follow-up. The use of a therapeutic weight loss diet is recommended for obese patients. These diets are typically high in protein (>30% metabolizable energy (ME)) with moderate to high amounts of total dietary fiber (>30g/1000kcal). Added soluble and insoluble fiber to a high carbohydrate diet (>50% ME) has been shown to improve glycemic control in dogs. Weight loss is an important goal in overweight/obese cats with DM and can help achieve and maintain diabetic remission in conjunction with appropriate medical management. Every 1kg increase in body weight has been associated with a 30% decrease in
insulin sensitivity which was normalized with weight loss. The timing of weight management however should be delayed in an overtly ill cat until stabilized. Diabetic remission typically occurs in cats during the first 3–4 months of therapy. A recent survey of veterinarians in the Southeastern United States revealed that 97% (87/90) of vets always or usually recommended dietary management at the time of DM diagnosis and 93% of respondents recommended diets marked as low carbohydrate (LC). A low carbohydrate (<15% ME) diet may be advantageous for cats with DM. Cats fed a LC-low fiber diet had a significantly higher remission rate of 68% compared to cats fed a moderate carbohydrate-high fiber diet (41%). Cats also appeared to be better regulated on the LC diet. The author typically recommends canned, low carbohydrate diets for weight loss in diabetic cats. In obese cats that only consume dry food, a low calorie density, high fiber weight loss diet is typically preferred to improve owner compliance. Both therapeutic low carbohydrate and high fiber weight loss diets contain moderate to high amounts of protein (>35% ME) to support LBM.

References
Raw Food Diets:
Is There Evidence to Support Their Use?
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Popularity of raw meat based diets
In the United States and Australia, raw food or bones were reported to be fed at least daily as part of the main meal in 9.6% of cats and 16.2% of dogs.1 Another 0.9% of cats and 7.4% of dogs received raw meat or bones as a treat or snack at least once weekly. Interestingly, these survey results were collected prior to the melamine pet food recall of 2007. It is reasonable to hypothesize that feeding practices amongst pet owners has changed over the last decade. Raw freeze-dried pet food retail sales increased 64% in 2014 from US$25 million to US$40 million while raw frozen pet food increased 32% from US$52 million to US$69 million.2 Given the increasing popularity of commercial raw pet food products, it is likely veterinary professionals are encountering pets fed a raw meat-based diet (RMBD) or treat commonly in practice.

Nutritional adequacy of raw meat based diets
The nutritional adequacy of commercial RMBDs can be determined based on the Association of American Feed Control Officials (AAFCO) guidelines for formulation or by feed trial. RMBDs labeled for intermittent or supplemental feeding are not nutritionally complete and balanced. The use of whole prey diets may be used by some owners feeding a RMBD. Whole 1-3 day old chicks and adult ground chicken were found to meet macronutrient requirements but were deficient in some mineral requirements, including manganese, copper, potassium and sodium compared to AAFCO requirements for adult cats.3 These diets were not evaluated for vitamin content. Research kittens consuming a diet solely of whole raw ground rabbit developed dilated cardiomyopathy secondary to taurine deficiency resulting in the death of one kitten.4 The diet of a prey animals (e.g., chicks, mice, or rabbits) sold for pet consumption may also influence their nutrient profile. Home-prepared diets, raw or cooked, can be obtained by owners through a number of sources including the Internet, pet magazines, and books written by veterinarians and non-veterinarians with varying levels of nutrition training. Several studies have evaluated the nutritional adequacy of home-prepared diets in companion animals finding numerous and significant nutritional imbalances.5-11 Evaluation of 200 published home-prepared recipes for adult maintenance in dogs written by veterinarians (64.5%) and non-veterinarians (35.5%) revealed at least one essential nutrient deficiency according to National Research Council or AAFCO guidelines in the majority of diets (95%), and 83.5% of recipes has multiple deficiencies.5 Analysis of 77 home prepared bone and raw food rations for dogs in Germany found that 76% had one or more nutritional imbalances.9 A home prepared raw food diet formulated by a now board-certified veterinary nutritionists and commercial raw food diet were determined to be nutritionally adequate based on a 10 week AAFCO feeding trial in kittens.10

Animals may develop clinical signs associated with nutrient deficiency or toxicity when consuming an unbalanced diet. Nutritional secondary hyperparathyroidism has been reported in both cats and dogs consuming unbalanced home prepared diets manifesting as spontaneous fracture, muscle twitching, seizures, and limb deformities.12,13 A dog consuming an unbalanced home prepared diet with deficiencies including calcium, phosphorus, and vitamin D developed tetanic seizures and hyperthermia during evaluation of bilateral humeral osteochondritis dissecans.14 Other reported nutrient imbalances resulting in clinical signs include metabolic osteopathy with extensive new bone formation from hypervitaminosis A in a cat consuming raw pork liver, pancreatitis in cats secondary to vitamin E deficiency while consuming a high poly-unsaturated fat raw diet, and hyperthyroidism in dogs consuming raw beef gullet with thyroid tissue.15-17

Potential benefits of raw meat based diets
Owners may choose to feed a RMBD to their pets due to anecdotal health benefits and to provide a more natural or ancestral diet. Many of these benefits remain unproven, although the body of scientific evidence surrounding RMBDs is limited. Cats and wolves in the wild will consume a variety of prey to support survival and reproduction, and some owners may choose to mimic this diet closely. However, this same type of diet may not be optimal for domestic animals expected to live long and healthy lives primarily indoors and reproductively altered.

Some owners may report a benefit of smaller stool volumes, less fecal odor, and improved gastrointestinal health in cats and dogs fed home-prepared or commercial RMBDs. Several studies have demonstrated a high digestibility of RMBDs fed to both exotic and domestic cats when compared to extruded diets.18,19 Digestibility of dry matter, organic matter, crude protein, and gross energy was significantly higher in a commercial and homemade raw food diet compared with a canned heat-processed diet in domestic kittens.20 Cats consuming whole ground rabbits had significant improvements in stool quality compared to cats consuming a commercial diet.4 Another study found no difference on total tract energy and macronutrient digestibility in cats fed a commercial raw beef-based diet or the same diet cooked in the microwave to at least 160°F.18 Significant differences have been noted in the fecal microbiota of cats fed a
raw diet consisting of 1-3 day old chicks compared to a chicken-based extruded diet although these differences could not be only attributed to the raw vs extruded nature of the diets as the nutrient composition differed.21

Heat processing of pet foods can result in Maillard reactions responsible for the browning of foods when heated. This reaction causes decreased bioavailability of lysine and formation of Maillard reaction products (MRPs) and advanced glycation end-products (AGEs) which may have harmful biological effects.22 A study found that dog and cats had an average daily intake of one MRP 122 and 38 times higher respectively than the average daily intake for adult humans.23 Further studies are needed to investigate the long-term health implications of this in dogs and cats. Heat processing of meat proteins can also negatively impact the creatine concentration of the dry dog food and meat/meat and bone meal, although the benefits of a creatine-rich diet is dogs is unknown.24 Researchers suggest this may also be due to Maillard reactions.

The infectious potential of raw meat based diets
Commercial and home prepared RMBDs may be contaminated with potentially harmful pathogens. The concern for public and animal health has led organizations such as the American Veterinary Medical Association and the American Animal Hospital Association to discourage the use of RMBDs.25–26 Studies have documented the presence of bacterial contamination in both commercial and home prepared RMBDs. A study by the United States Food and Drug Administration (FDA) in 2011-2012 found that out of 196 commercial RMBDs, 7.7% were positive for Salmonella spp., and 16% positive for Listeria monocytogenes.27 A study examining 25 commercial raw canine and feline RMBDs found contamination with Clostridium perfringens (20%), Escherichia coli (64%), Salmonella spp. (20%), Clostridium difficile (4%), and Staphylococcus aureus (4%) based on culture.28 Twenty-three percent of RMBDs for dogs contained extended spectrum cephalosporin-resistant E.coli.29 Salmonella in raw meats sold for human consumption has reported rates of 44% in chicken and 4% in beef and pork, therefore it is not surprising to find contamination in raw pet food.30,31 While the presence of Salmonella is allowed on meat for human consumption by the USDA, the FDA maintains a zero-tolerance policy on Salmonella in pet foods.32 The FDA lists 26 dog and cat food recalls from 2015 (expanded recalls are counted as 1 with the original recall), with the vast majority from RMBD.33 Eleven treat products were recalled, 10 of these from Salmonella contamination. Seven of the recalled treats due to Salmonella contamination were beef products including beef gullet, tripe, trachea, jerky, and bone. Twelve of 15 complete and balanced recalled commercial diets were RMBD. Seven RMBDs were recalled for Salmonella, 1 for Listeria monocytogenes, 3 for both Salmonella and Listeria, and 1 for thiamine deficiency.

Once fed a RMBD containing Salmonella, cats and dogs have been shown to shed the bacteria in their feces.10,34,35 Kittens fed a home prepared and commercial raw food diet had significantly higher globulin levels and red blood cell microcytosis compared to kittens consuming canned heat-processed diet.10 Positive fecal Salmonella Heidelberg and Clostridium difficile toxin was noted in the raw diet groups. Lab work changes were purposed to be associated with known enteropathogenic exposure. Seven of 16 dogs fed a known Salmonella-contaminated single meal shed the bacteria in their feces within 7 days of exposure.35 None of the dogs fed the Salmonella-contaminated meal experienced clinical signs. Feeding a commercial or home prepared RMBD is also a risk factor for antimicrobial-resistant Salmonella spp. and E. coli in the feces of dogs.36 In addition to the zoonotic potential, animals may be clinical affected. Three of twelve cats fed a raw food diet of whole or ground 1–3 day old chicks developed clinical salmonellosis (anorexia and diarrhea).37 Significant differences in the fecal microbiome were noted in the asymptomatic cats including the detection of other potentially pathogenic bacteria and increased proportions of other potentially pathogenic bacteria. Salmonella bacteriuria was reported in a cat with lower-urinary tract signs fed a Salmonella-contaminated uncooked granular diet by a company that manufactures RMBDs.38 Septicemic salmonellosis in two cats resulting in death after being fed a diet containing uncooked beef has also been reported.39 In one of the cases, Salmonella Newport was isolated and found to be identical to the bacteria isolated in the diet.

Clinical recommendations
The potential for human and animal disease with commercial and home-prepared RMBDs is well documented. Food utensils, feeding bowls, litter boxes, the RMBD, feces and animals with bacteria present in their mouths or on their coat are all sources of potential pathogen exposure for people. The risk of pathogen contamination is particularly a concern among elderly, young, pregnant, lactating, or immunocompromised pets and people. Policies to protect veterinary staff and hospitalized animals from pathogens shed in feces are recommended when treating an animal consuming a RMBD. The FDA also has resources on safe handling tips for pet food and treats and recommendations to owners who choose to feed a RMBD.40 Consultation with a board-certified veterinary nutritionists or individual with similar training for owners wanting to home prepared any diet, cooked or raw, is recommended.

References


414


Myth #1: Pet food labels are the best way to assess pet food quality and safety

Pet food labels tell the consumer very little about product safety and quality. The World Small Animal Veterinary Association (WSAVA) and American Animal Hospital Association (AAHA) has released a list of questions/guidelines to help consumers and veterinarians select commercial per food. These questions to pet food companies include:

1. Does the company employ a full time qualified nutritionists?
2. Who formulated the company’s foods and what are his/her credentials?
3. Are the diets tested using Association of American Feed Control Officials (AAFCO) feeding trials or by formulation to meet AAFCO nutrient profiles? If the latter, do the diets meet AAFCO nutrient profiles by formulation or by analysis of the finish product?
4. Where are the diets produced and manufactured?
5. What specific quality control measures does the company use to assure the consistency and quality of the ingredients and the end product?
6. Can the company provide an average/typical nutrient analysis for the dog or cat food in question or their lead product?
7. Can the company provide the calorie content of their diet by gram, can, or cup?
8. What kind of product research is conducted? Are results published is peer-reviewed journals?

The above questions go beyond the pet food label to give consumers and veterinary professionals additional insight into the company and the particular products in questions. The information gained from question 5 will likely be limited as the full scope of a company’s quality control measures can be quite extensive. Additional recommendations for assessing a company’s quality control standards have been mentioned in a recent article on raw-meat based diets for dogs and cats. These include manufacturer testing of ingredients and end-products for nutrient content, pathogens (e.g. salmonella), and aflatoxins, materials risk assessments, and supplier audits. Additionally the quality control procedures, such as Hazard Analysis Critical Control Points (HACCP) to identify hazards during production, should be certified by an organization such as the Global Food Safety Initiative or American Feeding Industry Association. As another resource to pet owners, AAFCO has a comprehensive consumer friendly website to address pet owner questions related to pet food (talkspetfood.aafco.org).

The FDA Food Safety Modernization Act (FSMA) was signed into law January 2011 with the primary aim of preventing foodborne illness in the U.S. The FDA maintains an extensive webpage with information regarding FSMA. This law also applies to pet food manufacturers. While the law itself is quite extensive, for animal food it ensures that manufactures establish current good manufacturing practices (cGMPs) and preventive controls. A regular company must comply with cGMPs by September 2016 and preventive controls September 2017. Small (<500 full time employees) and very small (< US$2,500,000 in sales including the manufacturing value of food produced but held without sale) business have a longer time to comply with all companies complying by September 2020. Additionally, the law will also bring improvements to product tracing to aid investigators in the event of an outbreak of food borne illness or contamination. This new law and its regulations will improve the quality and safety of pet food manufacturing in the U.S.

Myth #2: Coconut oil can be used widely in veterinary medicine for numerous disease processes and preventative measures

The author frequently encounters pet owners who supplement their cat or dog with coconut oil for a variety of unproven health benefits. Pet owners may also desire coconut oil as their pet’s primary fat source. Coconut oil is primarily composed of medium chain triglycerides (MCTs) containing 8-12 carbons versus long chain fatty acids (LCFA) containing 14-24 carbons. Coconut oil is a poor source of essential fatty acids including linoleic acid (18:2n-6). Approximately 2% of coconut oil is linoleic acid compared to 54% of corn oil, 19% of canola oil, and 10% of olive oil. Due to its low essential fatty acid content, coconut oil cannot be the sole source of fat in a cat or dog’s diet. Additionally, coconut oil provides calories (40kcal per teaspoon) which may contribute to overfeeding when supplemented into a pet’s diet.

Compared to LCFA, MCTs have increased water solubility, are more rapidly hydrolyzed and absorbed in the gastrointestinal tract, are not repackaged into triglycerides in the enterocyte, absorbed primarily by the portal vein rather than lymphatic vessels, and do not rely on L-carnitine for transport into the mitochondria for β-oxidation. These characteristics can be beneficial for some animals when included in their diet. MCTs are primarily recommended in patients with malabsorptive disease due to their improved digestibility. While some absorption of MCTs does occur through lymphatic vessels in dogs, they have been recommended in the management of intestinal lymphangiectasia. Increased blood concentrations of cholesterol and vitamin A and E were found in canine patients with exocrine pancreatic insufficiency consuming a diet with increased levels of MCTs, however no differences in clinical signs were observed. Long term supplementation with MCTs has been shown to improve canine cognition.
improvement is increased ketone body production providing an alternative energy source to neurons in the brain. MCTs have also been shown to have in vitro antimicrobial activity against canine and feline periodontal pathogens. While medium chain triglycerides have demonstrated some utility in veterinary medicine and studies are ongoing, grand claims of disease prevention or cure with coconut oil should be met with skepticism by pet owners and veterinary professionals.

Myth #3: Preservatives in pet food are unsafe
Preservatives, typically antioxidants, are included in pet foods to prevent spoilage and degradation of nutrients. They are necessary in dry pet foods and may be added to canned or other pet food products. Fatty acids require antioxidant preservation in pet food to prevent lipid peroxidation and rancidity. Both natural and synthetic preservatives are approved for use in both human and pet foods by the U.S. Food and Drug Administration. The pet food market has more recently favored the use of natural preservatives or no preservatives which significantly impacts the shelf life of a product and quality of nutrients over time. Natural preservatives used in pet foods include mixed tocopherols (vitamin E), citric acid, ascorbic acid (vitamin C) and rosemary extract. Synthetic preservatives include but are not limited to ethoxyquin, BHA (butylated hydroxyanisole), and BHT (butylated hydroxytoluene). Although numerous studies are available to demonstrate the safety of synthetic preservatives at approved amounts, they are not as commonly used as naturally derived preservatives. Naturally derived preservatives tend to be more expensive and foods with these preservatives will have a shorter shelf life than pet foods preserved with synthetic antioxidants. Dog food preserved with mixed tocopherols and vitamin C had a higher peroxide value and decreased palatability over a 12 month period compared to dog food preserved with ethoxyquin and BHA. There is also insufficient evidence at this time to demonstrate that naturally derived preservatives are safer in pet foods than synthetic preservatives. Overall, the use of preservatives in pet food is necessary for food safety and quality over time.

Myth #4: Raw and home cooked diet are better for dental health than commercial kibble based diets
With the high prevalence of dental disease in domesticated animals, many pet owners may conclude that the natural, raw-meat based diet of cats and dogs is beneficial for dental health. The skulls of 29 African wild dogs were evaluated for dental disease. The diet of these dogs was primarily wild antelope. Teeth wear was noted in 83% of teeth with fractures in 48%. In half of fractured teeth, signs of endodontic disease were present. Periodontitis was present in 41% of dogs, however only mild calculus was present in 2 dogs. Skulls of 310 feral cats from Marion Island in Canada were evaluated for dental disease. Approximately 95% of their diet consisted of birds. Periodontitis was present in 61.8% of cats and 14.8% of teeth, calculus 9% of cats and 0.79% of teeth, and resorptive lesions in 14.3% of cats and 1.2% of teeth. Evidence from these studies suggests that while the natural diet of cats and dogs may minimize dental calculus, it is not protective against periodontitis and tooth loss.

In a relatively large study by veterinary medicine standards, 17,184 dogs and 6,371 cats in Poland were evaluated in a conscious exam for dental deposits, mandibular lymph node enlargement, and gingival health. They were then assigned an Oral Health Index (OHI) score where a lower score indicated improved oral health. Cats had a significantly higher OHI score when fed a home prepared diet compared to any other combination of commercial foods or home prepared foods with added commercial food. In dogs, there was no difference in the OHI score between wet and home prepared foods. Introducing an element of dry food into the diet of both cats and dogs significantly improved their OHI score. Another study evaluated dental calculus, gingival inflammation, and periodontal bone loss in 1,350 client-owned dogs. Dogs on exclusively dry food diets did not have significantly improved oral health parameters when compared to other forms of food. At this time, there is no evidence to suggest that raw meat based or home prepared diets are better at preventing dental disease in companion animals when compared to commercial kibble based diets. While dental disease can occur in dogs and cats regardless of diet form, owners of pets on a home prepared diet should be advised of the potential increased risk for dental pathology. Additional dental health and prevention methods should be recommended.

Myth #5: A “wild-type” diet is better for cats and dogs than our currently available dry and canned pet foods
Pet owners may desire a more wild-type or evolutionary-based diet similar to the diet of wild cats or wolves for their pets. The diet of wolves or wild cats support survival and the ability to pass along their genes. The diet of our domesticated, primarily indoor, reproductively altered cats and dogs should not only support survival but optimize health for a long life. An evidence based nutritional strategy promotes our current knowledge for disease prevention and modification to promote overall wellbeing and longevity.

While dogs are members of the order Carnivora, their metabolism and nutritional needs approach those of omnivores. Domesticated dogs differ from wolves in that they are adapted to thrive on a starch rich diet. Genes that play a role in starch digestion including pancreatic amylase (AMY2B), maltase-glucoamylase (MGAM), and the sodium/glucose cotransporter (SGLT1) demonstrate changes including expression and activity that favor starch digestion in the dog when compared to wolves. The ability to handle a starch rich diet may have some breed variability as demonstrated by a wide variation of AMY2B activity amongst dog breeds. Cats, as true carnivores, are closer to their wild counterparts that dogs to wolves. Whole prey diets may be desired to mimic a wild-type diet. Whole 1-3 day old chicken and adult ground chicken were found to meet macronutrient requirements but were deficient in some mineral requirements, including manganese, copper, potassium and sodium compared to AAFCO requirements for adult cats. These diets were not evaluated for vitamin content. Research kittens consuming a diet solely of whole raw ground rabbit developed dilated...
cardiomyopathy secondary to taurine deficiency resulting in the death of one kitten. The diet of prey animals (e.g., chicks, mice, or rabbits) sold for pet consumption may also influence their nutrient profile. While it is possible to provide complete and balanced nutrition from a whole prey diet, pet owners should be advised of possible nutritional deficiencies that may occur and consultation with a board-certified veterinary nutritionists or individual with similar training can be recommended.

**Internet surfing tips for pet owners**

The World Small Animal Veterinary Association (WSAVA) provides handouts for pet food owners on surfing the internet for nutritional information. Recommendations for reviewing nutritional information on the internet include:

- Reviewing the credentials of the website’s author
- Read the website address (.com = commercial, .org = nonprofit organization, .edu = educational)
- Look for references to product or ingredient claims; if a reference is provided, is it evaluating the species of interest (i.e. cat or dog) or another species (i.e. humans or rodents)
- Understand the limitations of anecdotal or testimonial evidence
- Be skeptical of grand claims or easy solutions to complex problems
- Evaluating the timeliness of nutritional recommendations
- Understand the limitations of rating websites as this is often based on opinion or criteria that does not accurately reflect the quality or safety of a product

Pet owners should also be encouraged to discuss nutritional information or questions with their veterinarian. Several reputable internet resources are included with the WSAVA recommendations.

**References**

Most cat owners feed nutritionally complete and balanced commercial pet foods. A survey of feeding practices from the United States and Australia including 469 cat owners found that 98.8% of cats consumed at least half of their intake from commercial foods.1 Twenty-nine percent of cats received at least half of their diet from canned foods and 13.1% of cats were provided noncommercial foods (i.e., table scraps, leftovers, or home prepared foods) as part of their main diet. Data from this study was collected in 2004, prior to the large scale pet food recall in 2007 involving the illegal adulteration of pet foods with melamine. Since this recall, there appears to be a growing interest in alternative feeding practices that can range from simply providing a more natural commercial product to providing home prepared cooked or raw-meat based foods.

**Vegan and vegetarian diets**

Given the unique nutritional requirements of cats as obligate carnivores, vegan and vegetarian diets are not generally recommended by the author. However, veterinarians will encounter owners wanting to feed vegan or vegetarian diets. It is important to recognize why owners may be making these decisions and to know how to ensure they are meeting their cat’s nutritional needs. Results of a telephone survey indicated the primary reason owners choose to feed a vegetarian diet was due to ethical concerns.2 Other reasons cited included the perception that conventional cat foods are unwholesome and purported health benefits of a vegetarian diet. It may be difficult for veterinarians to persuade owners feeding vegetarian or vegan diets to change. Choosing a reputable commercial product or working with a board certified veterinary nutritionist or person with similar training is advised. Unfortunately, a recent study revealed that 6/6 commercial dry vegan or vegetarian pet food diets (4 canine, 1 feline, and 1 canine & feline) contained mammalian DNA (bovine, porcine, and/or ovine) not listed on the label.3 This is most likely due to unintentional cross-contamination of the diet during storage, transport, or processing. While this violates labeling requirements, it may also impact the trust of consumers wanting to feed a commercial vegan or vegetarian diet to their pet.

Two commercial vegan diets labeled to be nutritionally complete and balanced when compared to Association of American Feed Control Officials (AAFCO) nutrient profile for adult maintenance in cats have been independently evaluated.4 Investigators found that both diets contained multiple deficiencies including less than the AAFCO minimums for methionine, taurine, arachidonic acid, and pyridoxine. One diet, labeled for all life stages (adult maintenance including growth and reproduction) was found to be deficient in crude protein, lysine, methionine, taurine, arachidonic acid, calcium, phosphorus, vitamin A, niacin, pyridoxine, and vitamin B12 when compared to AAFCO nutrient profiles for growth and reproduction in cats. A study evaluating the crude protein and amino acid concentrations for commercially available dog and cat vegetarian diets found that while all cat diets (3 dry, 2 canned, 1 dry for dogs and cats, 1 canned for dogs and cats) exceeded the AAFCO minimum requirements for crude protein, all canned and 3 dry feline exclusive diets were deficient in at least 1 amino acid.5 All canned diets were below the minimum requirement for taurine. Interestingly, this study also found that only 11 out of 24 (dog and cat) diets evaluated met the current AAFCO labeling requirements. Based on this information, veterinarians should encourage owners feeding a vegan or vegetarian commercial diet to use products that have undergone both nutrient laboratory analysis and feeding trials before use rather than diets that have simply been formulated to meet the nutrient requirements.

Total protein intake, taurine, arachidonic acid, vitamin A, cobalamin, and niacin are of particular concern for cats on vegan or vegetarian diets as these ingredients are typically derived from meat sources. Whole blood taurine and serum cobalamin concentrations were measured in 17 cats fed a commercial vegetarian diet, vegetarian food prepared with a commercially available supplement, or a combination of the two for greater than one year.6 Serum cobalamin concentrations were within the reference range for all cats. Whole blood taurine concentrations were below the reference range in three cats, but above the point of clinical deficiency (200 nmol/L), suggesting that their intake of taurine was marginal. Cats fed meat-free diets should be regularly evaluated by a veterinarian to monitor for signs of nutrient deficiencies. The author recommends annual evaluation of complete blood count, biochemistry panel, urinalysis, whole blood taurine, and serum cobalamin levels, especially for those cats fed HPDs. As part of their regular physical exam, special attention should be given to the patient’s muscle condition score, skin, and hair coat to monitor for subtle signs of inadequate protein or essential fatty acid intake. Owners providing home prepared vegetarian or vegan diets should be offered referral to a board certified veterinary nutritionist or person with similar training for nutritional evaluation of their cat’s diet and to ensure proper supplementation of essential nutrients.

**Home prepared diets**

Home Prepared Diets (HPD) can provide complete and balanced nutrition when formulated and prepared properly. These types of diets can contain cooked or raw ingredients or a combination of both. Owners may choose to prepare their cats food due to distrust or concerns regarding commercial pet food products, to avoid additives, preservatives or potential contaminants, the ability to offer a

420
more natural or organic diet, as a way to strengthen the human-animal bond, out of habit to feed finicky eaters, or to manage a medical condition.6,7 A HPD may be recommended by a veterinarian for a variety of reasons including a food trial to rule out possible food allergy or intolerance, poor appetite for commercial therapeutic foods, or due to concurrent medical conditions where no commercial diet is available. Few studies are available evaluating the health impact of HPDs in cats. A study evaluating the oral health of 6,371 cats found a higher probability of an oral health problem in cats eating a HPD when compared to cats eating a commercial canned or dry food or a HPD in combination with a commercial food.8 The investigators reported cats fed a HPD had a significantly higher probability of an oral health problem (56%) compared to cats fed a dry commercial diet (24%). Many owners will report a benefit of smaller stool volumes, less fecal odor, and improved gastrointestinal health for pets fed home prepared cooked or raw meat-based diets.6

Nutritional imbalance of HPDs, raw or cooked, can lead to a variety of clinical manifestations. Nutritional secondary hyperparathyroidism has been reported in 6 cats manifesting as spontaneous fracture, muscle twitching, or seizures.9 Five of the cats were fed primarily home prepared meat, while the 1 cat was fed a home prepared vegan diet. Metabolic osteopathy with extensive new bone formation from hypervitaminosis A was reported in a 9-year-old, male castrated, domestic shorthair cat fed a HPD of raw pork liver.10 Pansteatitis secondary to vitamin E deficiency in the face of high polyunsaturated consumption has also occurred in cats consuming HPDs of pig brains or oily fish such as sardines, anchovies, and mackerel.11 Clinical cases of nutritional imbalances are considered to be rare in veterinary medicine due to the availability of complete and balanced commercial products.

Owners may obtain published recipes from a variety of sources including the Internet, pet magazines, and books written by veterinarians and non-veterinarian with varying levels of nutritional training. Twenty-eight diets promoted for use in cats with chronic kidney disease were evaluated and found to have deficiencies below the National Research Council (NRC) nutrient recommended allowances for crude protein (42.9%), choline (82.1%), selenium (32.1%), zinc (67.9%), and calcium (25%).12 An evaluation of 200 published home prepared recipes for adult maintenance in dogs written by veterinarians (64.5%) and non-veterinarians (35.5%) revealed at least one essential nutrient deficiency according to NRC or AAFCO guidelines in the majority of diets (95%), and 83.5% of recipes had multiple deficiencies.13 Unfortunately, many published recipes for companion animals for both health and disease are nutritionally inadequate.

When evaluating HPDs for cats, it is important to first identify the presence of essential nutrients including protein, fat, minerals, trace minerals, and vitamins. An animal-based protein source and supplemental taurine is recommended. Cats do not have a nutritional requirement for carbohydrates and HPDs can be formulated without their inclusion. However, carbohydrates can provide energy and serve as a source of dietary fiber, both soluble and insoluble, to optimize intestinal health.6 A source of linoleic acid should be provided by a specific vegetable oil such as corn or canola oil but can also be provided by some animal fats. Animal-based fat is required to provide arachidonic acid. Ingredient amounts should be specific and include both weight (grams or ounces) and common measurements where appropriate. Descriptions of ingredients should include of types of cuts and/or lean percentages. The recipe should indicate if the ingredient should be measured prior to or following cooking. Many feline vitamin and mineral supplements are inadequate to balance HPDs unless specifically formulated to do so. Human vitamin and mineral supplements have varying formulations, some potentially harmful to cats, therefore specific supplements should be recommended. Clients should be instructed to follow any recipe meticulously and to consult with their veterinarian before making any adjustments. The author recommends that home-prepared diets be obtained or evaluated by a board-certified veterinary nutritionist or a veterinarian with similar training able to recognize and minimize health risks through formulation and preparation. Follow-up veterinary evaluations should assess adherence to the recipe to minimize potential nutrient imbalances. Only 13% (4/30) of dog owners were found to adhere to a home cooked diet recipe from a university veterinary clinical nutrition service.14

Raw meat-based diets

Raw meat-based diets (RMBD) are growing in popularity amongst pet owners. Raw freeze-dried pet food retail sales increased 64% in 2014 from US$25 million to US$40 million while raw frozen pet food increased 32% from US$52 million to US$69 million.15 These diets may come in a number of forms including freeze-dried, frozen, as a component of an extruded diet, or fresh. Some owners may elect to feed a whole prey diet. In one study, whole one to three day old chicks and adult ground chicken were found to meet macronutrient requirements but were deficient in some mineral requirements including manganese, copper, potassium, and sodium compared to AAFCO requirements for domesticated cats.16 These diets were not evaluated for vitamin content. Research kittens consuming a diet solely of whole raw ground rabbit developed dilated cardiomyopathy secondary to taurine deficiency resulting in the death of one kitten.17 The diet of a prey animals (e.g., chicks, mice, or rabbits) sold for pet consumption may also influence their nutrient profile.

While studies have demonstrated a high digestibility of RMBD to both exotic and domesticated cats when compared to extruded diets18,19, concern remains regarding the safety of RMBD in companion animals. Consumption of bones in RMBD may present a health risk as they can obstruct or perforate the gastrointestinal tract and can damage teeth. Bone foreign bodies were present in the esophagus of 2/33 cats presenting to a referral practice for evaluation of esophageal disease.20 A number of studies have documented
the presence of bacterial contamination in both commercial and home prepared RMBD for dogs and cats. A recent study by the Food and Drug Administration found that out of 196 commercial RMBD, 15 (7.7%) were positive for Salmonella and 32 (16%) positive for Listeria monocytogenes.21 Another study examining 25 commercial raw canine and feline RMBD found Clostridium perfringens in 20% of diets, Escherichia coli in 64%, Salmonella spp. in 20%, Clostridium difficile in 4%, and Staphylococcus aureus in 4% based on bacterial culture.22 Consuming a RMBD has also been shown to be a risk factor for Toxoplasma gondii infection in cats.23 Once fed a RMBD containing Salmonella, cats can shed bacteria in their feces.24 Septicemic salmonellosis in two cats resulting in death after being fed a diet containing uncooked beef has been reported.25 Three of twelve cats fed a raw food diet of whole or ground 1-3 day old chicks developed clinical salmonellosis (anorexia and diarrhea).26 Salmonella bacteriuria was reported in a cat with lower-urinary tract signs fed a Salmonella-contaminated uncooked granular diet by a company that manufactures RMBDs.27

Veterinarians should evaluate a RMBD for nutritional adequacy and inform pet owners of the possible risks associated with feeding a RMBD. Food utensils, feeding bowls, litter boxes, the diet, feces and cats with bacteria present in their mouths or on their coat are all sources of potential pathogen exposure for people. The risk of pathogen contamination is particularly a concern among elderly, young, pregnant, lactating, or immunocompromised pets and people. Policies to protect veterinary staff and hospitalized animals from pathogens shed in feces are recommended when treating an animal consuming a RMBD. If home preparing a RMBD, consultation with a board-certified veterinary nutritionist or person with similar training should be recommended.

References
