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Assessment of commercial diets and recipes for home-prepared diets recommended for dogs with cancer

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Cancer is becoming increasingly common in both human and veterinary medicine. In the United States, it has been reported that cancer accounts for approximately 1 in 4 human deaths. One in 2 men and 1 in 3 women will develop cancer during their lifetime.[1] Similarly, cancer is the leading cause of death in dogs > 2 years old, and in some breeds, such as Golden Retrievers, the rate of death attributable to cancer is > 50%.[2]

Diet can alter cancer risk in humans and laboratory animals, and many investigators are exploring nutritional strategies to prevent cancer as well as aid in the treatment of cancer. A pet owner will often pursue dietary strategies that are believed to have the potential to benefit a pet with cancer. Anecdotally, dietary strategies often proposed for pets with cancer include low-carbohydrate diets, grain-free diets, raw-food diets, dietary supplementation with omega-3 fatty acids, and forgoing commercial pet foods in favor of preparing food at home for a pet.

Clients who opt to prepare food for their dogs with cancer do so for various reasons. Some pet owners believe that a commercial diet contributed to the development of the cancer, despite a general lack of evidence to support this belief. Others believe that avoiding preservatives and ingredients perceived to be undesirable (eg, grains) will improve their pet's prognosis. Still others want a way to be a direct part of their pet's treatment or are concerned because their pet's appetite is decreased and a home-prepared diet is perceived by the owner to be more palatable. Regardless of the reason for the decision to prepare their pet's food at home, once this decision is made, many pet owners seek advice on the preparation of meals from veterinarians, websites, books, newsgroups, and other sources.

Most commercial over-the-counter diets are complete and balanced (ie, they meet the minimum amounts established by the AAFCO[3] for all nutrients for the appropriate life stage). Manufacturers must verify that their products meet AAFCO nutritional guidelines by being formulated to meet the nutrient requirements in the published profiles or by passing animal feeding tests that use AAFCO protocols.[3] If neither of these situations is met, then the diets are not considered complete and balanced and the nutritional adequacy statement must state that the product is for intermittent or supplemental use.

Abbreviations

AAFCO	Association of American Feed Control Officials
ALA	α-Linolenic acid
DHA	Docosahexaenoic acid
EPA	Eicosapentaenoic acid
ME	Metabolizable energy
NRC	National Research Council
RA	Recommended allowance
SUL	Safe upper limit

In addition to AAFCO, the NRC also publishes nutritional recommendations for dogs.[4] The NRC publication includes an RA for each essential nutrient as well as minimum, adequate intake, and SUL amounts for some nutrients. Although not binding on manufacturers, NRC values can be used to determine nutritional adequacy of home-prepared diets. In several studies,[5–7] investigators found that many home-prepared diets are lacking in essential nutrients. However, none of these studies was conducted to specifically examine diets intended for dogs with cancer. The information reported here will address the nutritional adequacy and nutritional composition of commercial diets and recipes for home-prepared diets intended for dogs with cancer.

Identifying Sources of Information for Feeding Dogs with Cancer

An Internet search was performed to identify websites that discussed nutritional aspects of caring for a dog with cancer. Terms used for a Boolean search were diet OR *diet OR *diets OR recipe OR *recipe OR *recipes, dog OR *dog OR *dogs OR canine, and cancer OR *cancer OR tumor OR *tumor. Additionally, books and magazines for pet owners and veterinarians that included information on treating pets with cancer were

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identified through local libraries, bookstores, and online booksellers.

Evaluation of Recipes for Home-Prepared Diets

Recipes for home-prepared diets intended for dogs with cancer were obtained from the aforementioned sources. Some recipes could not be analyzed because of vague descriptions of ingredients and measurements (eg, 1 part meat to 1 part vegetables). Only those recipes that had ingredients and preparation instructions specific enough to allow for computer analysis (with some assumptions) and that did not clearly state that they were not intended to be complete and balanced or were to be used as treats were included. When > 1 recipe was provided by a book or a website, 2 recipes were selected from that source for analysis. In some cases, recipes from different sources appeared to be variations of the same recipe. Identical recipes were analyzed only once. However, similar recipes with differences in ingredients or measurements were analyzed separately.

Commercially available proprietary diet formulation software[a] was used for all recipe analysis. This software used an open-source nutrient database[b] and also allowed for manual input of foods and products not available in the open-source database. All ingredients clearly indicated as optional were omitted from the recipe analysis. Some recipes included > 1 ingredient option (eg, chicken, beef, or pork). In those cases, ingredients that were more commonly available or that had more complete nutrient profiles in the database were selected. Some amounts were given as ranges; in those cases, the mean was used (eg, 500 to 1,000 mL was analyzed as 750 mL). Some recipes indicated provision of an unspecified multivitamin formulated for pets, children, or adult humans. In those cases, the same popular canine and human products were used (default vitamins).[c–e] A leading national brand of the human products was selected because these products were readily available nationwide at grocery, drug, and discount stores and would therefore be likely to be used by pet owners. The default pet multivitamin was selected because this was a popular product sold through veterinarians and was marketed by the manufacturer as appropriate for fortifying diets of pets fed home-prepared meals. When the type and amount of a multivitamin was not specified (eg, diet instructions were to add a multivitamin), then the default pet multivitamin was used at a dose recommended by the manufacturer for the size of animal for which the recipe was intended. Specifically named supplement-type products were included in some recipes, and the nutritional profiles for those products were obtained from the manufacturer and entered into the computer software database when possible. Otherwise, information for a default human or animal supplement–type product was included. The amounts of some nutrients in some human foods were not available in the database (ie, undefined nutrients), which made it impossible to determine the exact amount of that nutrient in the recipe. This issue was most common with chloride and iodine, which were rarely measured in human foods. Some recipes had ≥ 1 ingredient with undefined nutrients, which was noted. In some cases, recipes met the AAFCO nutrient profile or NRC RA for a specific nutrient without providing the exact amount of that nutrient in the undefined ingredients because other ingredients in the recipe provided adequate amounts of that nutrient. However, in those cases, it could not be determined whether the total amount of the nutrient in the recipe was excessive.

Credentials of the recipe author or source (veterinarian vs nonveterinarian), stated caloric content, and size of animal for which the diet was intended were collected. Clarity of the description of ingredients, supplement-type products, and measurements (ie, the likelihood that a pet owner could make a consistent, balanced diet from the recipe) was subjectively assessed. Standard maintenance energy requirements (98 × body weight [in kg]$^{0.75}$ or 1.4 × resting energy requirement) were calculated for the size of dog for which each diet was recommended; these values were compared with the stated daily calorie content of the diet as well as the calorie content determined from recipe analysis.

All home-prepared diet recipes were analyzed for macronutrient distribution (percentage protein, fat, and carbohydrate on an ME basis), caloric density (as-fed and dry-matter basis), and micronutrient content. Specific physiologic fuel values for human food ingredients (ie, kcal/g of carbohydrate, protein, and fat) were used when available[8]; otherwise, standard Atwater factors were used for human foods. Essential nutrient concentrations were assessed on an energy basis (ie, g/Mcal) to allow comparisons between diets with different energy densities. Nutrient profiles of the recipes were compared with AAFCO nutrient profiles and the NRC RA for each nutrient for adult maintenance to assess nutritional adequacy.

Evaluation of Commercial Diet Recommendations

Caloric density, macronutrient distribution (percentage protein, fat, and carbohydrates on an ME basis), and nutritional adequacy were determined for commercial diets recommended on websites and in books or magazines. Macronutrient composition was evaluated on the basis of a typical nutrient analysis or a guaranteed analysis (including ash) provided by the manufacturer. Metabolizable energy (kcal/kg on an as-fed basis) was provided by the manufacturer. Nutritional adequacy was assessed on the basis of AAFCO statements on the package label, information provided by the manufacturer on a website, or information obtained from the manufacturer via telephone or email.

Adherence to Commonly Reported Strategies

Adherence to commonly proposed (but unproven) strategies for nutritional management of cancer in dogs (low-carbohydrate diets, grain-free diets, raw-food diets, and dietary supplementation with omega-3 fatty acids) was assessed for commercial diet recommendations and home-prepared diets. Grain-free diets were defined as recipes or commercial diets that did not contain ingredients obviously derived from grains (eg,

named grains, grain protein, or other grain fractions such as hulls or starch). Low carbohydrate was defined as < 20% of calories from carbohydrates on an ME basis. Diets were considered supplemented with omega-3 fatty acids when an obvious source was listed among the ingredients (eg, canola oil, fish oil, marine fish, fish meal, or flax). Manufacturers of commercial diets were asked to provide the concentration of total omega-3 fatty acids as well as ALA, EPA, and DHA concentrations in the diet. Amounts of total omega-3 fatty acids, the combination of EPA plus DHA, and ALA in recipes for home-prepared diets were determined via computer analysis of the recipes.

Recipes for Home-Prepared Diets

Twenty-seven recipes for home-prepared diets were obtained from various sources (11 from books and 16 from websites), 10 (37.0%) of which were formulated or provided by veterinarians. None of the 27 recipes met all essential nutrient requirements for adult maintenance as determined on the basis of AAFCO nutrient profiles or NRC RAs.

Clarity was lacking for the listing of ingredients and supplement-type products for most recipes for home-prepared diets. Sixteen of 27 (59.3%) recipes allowed for substitution of major ingredients, such as the types of meats, oils, or vegetables. Even the other 11 (40.7%) recipes that did not allow for substitutions often required multiple assumptions with regard to the type of meat (eg, type of chicken meat or percentage of fat in lean ground beef), ingredient variety (eg, rice [brown vs white, long-grain vs short grain, and enriched vs unenriched]), or cooking method. Many recipes also included imprecise units of measurement (eg, the volume of chopped meat or the number of broccoli spears). Four recipes did not include mention of the need for supplement-type products, and most recipes did not provide sufficient detail about supplement-type products to ensure that a typical pet owner would purchase the appropriate products.

The data were analyzed via a commercial spreadsheet[g] and statistical software.[h] Results of tests for normality (Anderson-Darling test) revealed that most of the variables were not normally distributed; therefore, all data were reported as median and range. Recipes had wide variations in caloric density (**Table 1**). Twenty-two (81.5%) recipes stated the weight of dog for which the diet was intended, and 5 of 27 (18.5%) recipes stated the expected caloric content or caloric density of the diet. Of the 5 recipes that stated the expected caloric density or total calories, none were within 10% of the calories determined by the formulation software (median difference, 21.0%; range, –43.2% to 24.8%). The calculated calories that the recipes would be expected to provide ranged from –169.3% to 52.2% of the calculated standard maintenance energy requirement for the size of dog for which the recipe was intended (22 recipes), and only 6 recipes reported an amount of calories within 10% of the calculated energy requirement.

The nutrient distribution (percentage ME) varied dramatically among the 27 recipes for home-prepared diets (Table 1). Most recipes met both AAFCO nutrient profiles and NRC RAs for total protein content (**Table 2**). Methionine, the combination of methionine and cysteine, and tryptophan were the amino acids most commonly deficient in recipes for home-prepared diets. The 3 recipes that were deficient in methionine or the combination of methionine and cysteine and the recipe for one of the tryptophan-deficient diets used tofu, rather than an animal protein, as a main protein source, and all 4 recipes were lower in total protein content than the AAFCO or NRC recommendations. The other 2 recipes that were deficient in tryptophan, compared with AAFCO or NRC recommendations, were beef-based diets that were otherwise adequate in total protein content.

One recipe for a home-prepared diet exceeded the NRC SUL for total fat (Table 2). Despite all recipes being adequate in total fat, not all recipes met AAFCO nutrient profiles and NRC RAs for linoleic acid. The amounts of the omega-3 fatty acids ALA, EPA, and DHA were commonly below the NRC RAs. Ten (37.0%) recipes contained adequate amounts of ALA; however, all recipes contained at least 1 ingredient in which the ALA content was not defined. Therefore, additional recipes may also

Table 1—Caloric distribution, caloric density, and the proportion of diets that adhered to each nutritional strategy for 27 recipes of home-prepared diets and 39 commercial diets recommended for dogs with cancer.

Variable	Recipes for home-prepared diets	Commercial diets
Nutrient distribution (%ME)		
Protein	33.6 (7.6–60.9)	32.4 (15.9–55.9)
Fat	45.8 (17.6–82.7)	46.5 (23.3–83.5)
Carbohydrate	14.9 (3.4–65.7)	14.9 (0.2–48.4)
Caloric density (Kcal/kg)*		
As-fed basis	1,540 (780–2,580)	1,678 (752–4,924)
Dry-matter basis	4,916 (4,109–6,849)	4,900 (2,308–7,600)
Nutritional strategy		
Supplemental omega-3 fatty acids†	24 (89)	33 (85)
Low carbohydrate	17 (63)	25 (64)
Grain free	18 (67)	27 (69)
Raw	4 (15)	8 (21)

Data are reported as median (range) for nutrient distribution and caloric density and as No. (%) for nutritional strategy.
*To convert values to Kcal/lb, divide value by 2.2. †Six commercial diets did not have obvious sources of omega-3 fatty acids on the ingredient list, and the manufacturers did not provide data on the total omega-3 fatty acid concentration in the diet.

have met the NRC RA had this information been provided. Six (22.2%) recipes for home-prepared diets exceeded the NRC SUL for the content of the combination of EPA and DHA. The AAFCO does not have minimum or maximum requirements for ALA, EPA, or DHA content.

Minerals composed the bulk of deficient essential nutrients in the recipes for home-prepared diets (**Table 3**). Most (19/27 [70.4%]) recipes of home-prepared diets had an inadequate calcium-to-phosphorus ratio of < 1:1. One of the recipes that had a ratio > 1:1 was de-

Table 2—Calculated nutrient concentrations (as-fed basis) in 27 recipes of home-prepared diets recommended for dogs with cancer.

Nutrient	No. of diets with nutrient amount defined for all ingredients	No. of diets above NRC RA	No. of diets above AAFCO recommendation	Median (range)
Protein (g/Mcal)	27	26	24	80.56 (21.79–150.14)
Arginine (g/Mcal)	27	27	27	4.955 (1.480–8.963)
Histidine (g/Mcal)	27	27	27	2.305 (0.599–4.194)
Isoleucine (g/Mcal)	27	27	26	3.773 (1.044–7.368)
Methionine (g/Mcal)	27	24	—	2.035 (0.451–4.066)
Combination of methionine and cysteine (g/Mcal)	27	25	25	2.998 (0.769–5.695)
Leucine (g/Mcal)	27	27	27	6.445 (1.711–12.158)
Lysine (g/Mcal)	27	27	26	6.376 (1.605–12.562)
Phenylalanine (g/Mcal)	27	26	—	3.498 (1.023–6.424)
Combination of phenylalanine and tyrosine (g/Mcal)	27	26	26	6.415 (1.808–12.492)
Threonine (g/Mcal)	27	26	26	3.286 (1.009–7.677)
Tryptophan (g/Mcal)	27	25	24	0.744 (0.262–1.636)
Valine (g/Mcal)	27	26	27	4.312 (1.200–8.310)
Fat (g/Mcal) *	27	27	27	50.991 (19.872–91.956)
Linoleic acid (g/Mcal)	24	20	19	3.637 (0.986–10.362)
Combination of EPA and DHA (g/Mcal)†	26	16	—	0.911 (0–8.860)

*One recipe exceeded the NRC SUL for fat. †Six recipes exceeded the NRC SUL for the combination of EPA and DHA.
— = Not applicable because nutrient is not included in the AAFCO nutrient profiles.

Table 3—Calculated vitamin and mineral concentrations (as fed-basis) for recipes of 27 home-prepared diets recommended for dogs with cancer.

Nutrient	No. of diets with nutrient amount defined for all ingredients	No. of diets above NRC RA	No. of diets above AAFCO recommendation	Median (range)
Calcium (g/Mcal)	27	10	3	0.717 (0.183–3.226)
Phosphorus (g/Mcal)	27	25	7	1.072 (0.401–2.574)
Calcium-to-phosphorus ratio	27	—	—	0.76 (0.17–1.81)
Magnesium (g/Mcal)	27	18	24	0.185 (0.078–0.552)
Sodium (g/Mcal)	27	27	27	0.499 (0.041–3.083)
Potassium (g/Mcal)	27	27	16	1.879 (1.160–4.275)
Iron (mg/Mcal)	27	19	2	10.83 (4.29–29.24)
Copper (mg/Mcal)	27	11	10	1.21 (0.40–30.92)
Zinc (mg/Mcal)	27	13	2	14.40 (3.01–48.48)
Manganese (mg/Mcal)	24	18	17	1.589 (0.301–7.825)
Selenium (mg/Mcal)*	24	18	25	0.111 (0.052–0.411)
Vitamin A (μg/Mcal)†	27	24	23	1,215 (84–16,109)
Vitamin D (IU/Mcal)‡	17	13	13	143 (41–2,348)
Vitamin E (IU/Mcal)*§	18	20	18	32.02 (1.63–622.00)
Vitamin B_1 (mg/Mcal)	27	16	25	1.278 (0.268–95.753)
Vitamin B_2 (mg/Mcal)	27	23	27	2.692 (0.656–96.099)
Vitamin B_3 (mg/Mcal)	27	27	27	25.51 (4.840–110.991)
Vitamin B_5 (mg/Mcal)*	25	25	26	8.718 (1.353–99.713)
Vitamin B_6 (mg/Mcal)	27	27	27	3.076 (0.882–96.695)
Vitamin B_{12} (μg/Mcal)	27	22	24	0.021 (0.002–67.858)
Folic acid (μg/Mcal)*	24	27	27	209 (81–1,352)
Choline (mg/Mcal)*	21	10	19	418.0 (189.7–2,025.9)

*Amount of this nutrient was not available for every ingredient in every recipe, but some recipes met the AAFCO recommendation and NRC RA through other ingredients without including the contribution of this specific ingredient. †One recipe exceeded the NRC SUL for vitamin A. ‡Two recipes exceeded the AAFCO maximum amount for vitamin D, and 3 diets exceeded the NRC SUL for vitamin D. §Two recipes exceeded the AAFCO maximum amount for vitamin E.
— = Not applicable.

ficient in both calcium and phosphorus content, compared with NRC RA and AAFCO recommendations. Iodine and chloride contents could not be evaluated because they were not defined (measured) in ≥ 1 ingredient in all but 2 and 4 recipes, respectively.

Vitamin D and choline were the vitamins most commonly deficient in recipes of home-prepared diets. It was also common that dietary ingredients were undefined for vitamin D and choline. Vitamin D was the vitamin that most commonly exceeded the AAFCO maximum amount or NRC SUL. Three of 17 recipes in which vitamin D was defined in all ingredients exceeded the NRC SUL, and 2 of 17 exceeded the AAFCO maximum amount for vitamin D. It is possible that additional recipes may have exceeded the SUL or maximum amount if vitamin D had been defined in all the ingredients for all recipes. Some recipes were below the NRC RA and AAFCO minimum amount and above the NRC SUL or AAFCO maximum amount for vitamins E (defined in 18 recipes) and A (defined in all 27 recipes).

Recommendations for Commercial Diets

Recommendations for use in dogs with cancer were found for 36 specific commercial diets (13 canned, 16 dry, 4 freeze-dried raw, and 3 premixes [all premixes required that meat be added to complete the diet]). Basic nutritional information (ie, caloric information, ingredient list, and a typical nutritional or guaranteed analysis including ash) was available for 33 of 36 (91.7%) commercial diets. An adequate amount of nutritional information was unavailable for the 3 premix diets; therefore, these diets were excluded from further analysis. Recommendations for 6 additional specific brands and forms of diets (1 frozen raw and 5 canned diets), but not specific flavors of those diets, were also identified. These recommendations were sufficiently specific to identify all flavors that fit into a category; thus, all flavors of a specific diet were combined into median values for that particular brand and type of diet (ie, product A grain-free canned diets) and were then included as compilation diets. Therefore, there were 39 commercial diets for which adequate information was available. All 39 of these diets, except for 1 veterinary therapeutic diet,[f] were readily available from local stores or online sources.

The sources of the recommendations for these diets included 4 websites, 2 books, and 1 magazine (excerpts of which were available online); only 1 source was associated with a veterinarian, and that source recommended the veterinary therapeutic diet. Recommendations for some diets were included in multiple sources but were included only once in the analysis. Two diets were manufactured by the same company and marketed by that company as good options for dogs with cancer, but there was no obvious conflict of interest for the remainder of the recommendations.

Only 2 of 39 (5.1%) commercial diets had passed AAFCO feeding trials (one for adult maintenance and the other for all life stages). The majority (35/39 [89.7%]) of the diets were formulated to meet AAFCO nutrient profiles for all life stages (27 diets) or adult maintenance (8 diets). Two diets, including one of the compilation diets, did not meet AAFCO nutrient requirements for any life stage, nor had those diets passed AAFCO feeding trials. These 2 diets were appropriately labeled for intermittent and supplemental feeding only.

Protein, fat, and carbohydrate content ranged widely among the commercial diets (Table 1). The median caloric density on an as-fed basis was 3,898 kcal/kg (1,772 kcal/lb) with a range of 3,328 to 4,924 kcal/kg (1,513 to 2,238 kcal/lb) for the dry diets and 1,295 kcal/kg (589 kcal/lb) with a range of 752 to 2,245 kcal/kg (342 to 1,020 kcal/lb) for the wet diets (including the frozen raw diet and the dehydrated and freeze-dried raw diets rehydrated as instructed per the manufacturer's recommendations).

Adherence to Common Nutritional Strategies for Cancer

Raw, low-carbohydrate, grain-free, and omega-3 fatty acid–supplemented diets were feeding strategies commonly represented among the recipes for home-prepared diets and the commercial diets (Table 1). Tests were performed to determine whether these strategies were represented more often in recipes from veterinarian sources than from nonveterinarian sources. Recipes of home-prepared diets formulated or provided by veterinarians were as likely to be low in carbohydrates (7/27) as those formulated or provided by nonveterinarians (10/27; $P = 0.69$; χ^2 test). Twelve of 18 grain-free diets were also low in carbohydrates. Five of 10 diets formulated or provided by veterinarians were grain-free, compared with 13 of 18 diets formulated or provided by nonveterinarians, but this difference was not significant ($P = 0.22$; χ^2 test).

Two recipes recommended that the meat portion of the diet be fed raw, and 2 other recipes provided owners with the option of feeding the meat raw or cooked. One of these recipes, which was provided by a veterinarian, suggested that the diet should ideally be served raw but recommended cooking the diet for pets receiving chemotherapy.

Most (24/27) recipes for home-prepared diets included dietary supplementation with omega-3 fatty acids in the form of ALA, EPA, or DHA. Various types of fish oil (n = 14 recipes) or marine fish (3) were listed as a source of EPA and DHA, and flaxseed oil (5) or canola oil (7) were listed as a source of ALA (5 recipes included > 1 source of omega-3 fatty acids). The median concentration of the combination of EPA and DHA in the recipes was 0.91 g/Mcal (range, 0 to 8.86 g/Mcal).

Eight commercial diets contained raw meat (frozen or freeze-dried). Three of those diets, all made by the same manufacturer, were extruded kibble diets with a freeze-dried raw-meat coating added to the kibble after extrusion. Most commercial diets contained < 20% carbohydrates and did not contain any grains on the ingredient list. Eight commercial diets were grain-free but not low in carbohydrates.

Total omega-3 fatty acid concentrations were available for 28 of 39 (71.8%) commercial diets, which included 1 compilation diet. Median omega-3 fatty acid concentration for these 28 diets was 1.51 g/Mcal (range, 0.32 to 17.94 g/Mcal). The remaining diets were not

analyzed by the manufacturer, or the manufacturer did not provide the requested information. Five commercial diets for which omega-3 concentrations were not available contained obvious sources of omega-3 fatty acids (eg, flax); thus, there were 33 commercial diets that contained omega-3 fatty acids. The proportion of the omega-3 fatty acids comprising DHA, EPA, and ALA, the most common omega-3 fatty acids found in pet foods, was available for only 6 of 33 (18.2%) diets (none of which were a compilation diet). Four of 33 (12.1%) commercial diets were supplemented with fish oil, and 16 (48.5%) contained supplemental flaxseed or flaxseed oil. Nine (27.3%) commercial diets contained fish or fish meals that would be expected to contain omega-3 fatty acids (assuming the use of wild-caught fish or fish products [ie, salmon, menhaden, and ocean fish meal]), 6 (18.2%) contained canola oil, and 6 (18.2%) contained no obvious sources of omega-3 fatty acids. Many diets contained > 1 potential source of omega-3 fatty acids.

Assessment of Diets for Dogs with Cancer

Published recipes of home-prepared diets for pets with various health conditions are rarely nutritionally adequate. None of the 27 recipes identified and evaluated met NRC RA or AAFCO nutrient profiles for all essential nutrients. In some cases, the recipes contained excessive, potentially toxic amounts of nutrients. Recipes formulated or provided by veterinarians were not more nutritionally sound than were recipes formulated or provided by nonveterinarians.

There is a paucity of experimental data that support specific nutrient profiles or ingredients for dogs with cancer. Dogs with cancer do not have higher or lower requirements for protein, fat, calories, or any other specific nutrients, compared with requirements for healthy dogs. Therefore, it is of concern that none of the recipes for home-prepared diets met NRC RA or AAFCO nutrient profiles for adult maintenance in dogs. Two of the commercial diets also did not meet AAFCO nutrient profiles (adherence to NRC RA could not be assessed). All of these inadequate diets have the potential to cause nutritional disease at a time when nutrition should be optimized to provide maximum metabolic support and immune system function and to help decrease adverse effects attributable to cancer treatments. Moreover, the recipes for the home-prepared diets do not include a statement indicating that the diets are for intermittent or supplemental feeding only, which would help pet owners identify inadequate diets.

Subjectively, the total fat and protein content was higher and carbohydrate content lower in the commercial diets and recipes of home-prepared diets formulated for dogs with cancer than in typical commercial adult maintenance diets for dogs, which likely is a response to currently popular strategies of feeding low-carbohydrate, high-fat diets to dogs with cancer. In addition to a decrease in the carbohydrate content, many of the commercial diets and recipes for home-prepared diets also reflected commonly recommended strategies, such as avoiding grains and providing dietary supplementation with omega-3 fatty acids.

Commercial diets and recipes of home-prepared diets reflected the current popularity of grain-free diets. No data support health benefits of nongrain sources of carbohydrate over carbohydrates provided by grains; however, many manufacturers still tout the nutritional superiority of grain-free products. Grain-free diets are often marketed as lower in carbohydrate content, but this is not a consistent finding. Approximately one-third of the recipes of grain-free home-prepared diets and commercial diets did not meet the defined criteria for low-carbohydrate diets.

Low-carbohydrate diets are commonly recommended for dogs with cancer on the basis that many cancer cells use aerobic glycolysis and fermentation of pyruvate to lactate as a main source of energy, rather than the much more efficient oxidative phosphorylation used by most physiologically normal cells.[9] This phenomenon is known as the Warburg effect, which is named after Nobel laureate Otto Heinrich Warburg, who discovered it in the 1920s. Energy production solely via glycolysis requires large amounts of glucose, and it is theorized that feeding a low-carbohydrate diet could effectively starve cancer cells through a decrease in the supply of glucose. However, despite the fact that this theory has been in existence for nearly a century, minimal data have been published to support the tangible benefits of low-carbohydrate diets for any species of animal with cancer. To our knowledge, there are no published data to support the contention that low-carbohydrate diets are of clinical benefit with regard to tumor growth, disease-free interval, or survival time in dogs, and further studies are required before appropriate recommendations can be made. Additionally, low-carbohydrate diets, with their typically high concentrations of fat, may not be tolerated by some dogs and could lead to gastrointestinal distress, pancreatitis, or hyperlipidemia.

The omega-3 fatty acids ALA, DHA, and EPA have been investigated for their use in cancer prevention and as adjuvants to cancer therapy in multiple species.[10–12] In 1 study,[13] investigators evaluated the use of a diet supplemented with large amounts of fish oil (DHA and EPA) and arginine (a version of that diet is commercially available and was one of the veterinary therapeutic diets assessed in the present report) versus a control diet of similar macronutrient profile in dogs with lymphoma. Analysis of data from that study[13] revealed longer median survival times in dogs with stage IIIa lymphoma fed the supplemented diet as well as a positive linear association between serum DHA concentration and survival time in dogs fed the supplemented diet. This benefit was not evident in dogs with stage IV lymphoma, although the method by which the cancer was staged (ie, abdominal radiography rather than ultrasonography) and the use of post hoc analysis have been criticized. Given that the diet in that study[13] was supplemented with both omega-3 fatty acids and arginine, it is not possible to distinguish the effects of each, and no other detailed reports of the use of this diet have been published. It should be mentioned that even if diets supplemented with omega-3 fatty acids have no benefit for dogs with cancer, increasing the intake of EPA and DHA appears to be beneficial for general well-

ness and adverse reactions are uncommon. Supplementation with DHA and EPA in commercial diets designed for healthy pets is becoming increasingly common, and supplementation of diets formulated for pets with cancer is unlikely to be harmful. If supplemented diets are desired, the best results will likely be obtained for supplementation with EPA and DHA directly because the conversion of ALA (flax) to EPA and DHA is poor in dogs.[14]

The number of recommendations for feeding raw meat diets to cancer patients is a concern because contamination with pathological bacteria has been reported for raw meat for human consumption and for commercial raw diets.[15,16] Cancer patients, even those not receiving chemotherapy, likely have some degree of altered immunoregulation, and many dogs receiving chemotherapy are clinically immunosuppressed, which dramatically increases the risk of illness or even death from contaminated food sources. In humans, the risk of illness attributable to foodborne bacteria in cancer patients is such a concern that patients receiving chemotherapy are commonly advised to eat raw fruits and vegetables only when at home.[17]

The method of diet analysis (use of computer software rather than actual analysis of the finished diet) has some notable limitations. First, there is the limitation of the nutrient database available. A human database was used, and in many cases, not all of the essential nutrients for dogs and cats were routinely measured in all ingredients analyzed. However, it can be assumed that the individuals creating the recipes likely had similar concerns, assuming they used formulation software or a spreadsheet to determine the final nutrient profile of the diets. Because of the high cost for analysis of all essential nutrients in a diet, it is extremely unlikely that any of the home-prepared diets would be analyzed as a whole diet to determine exact nutrient content. The likelihood of potential nutrient differences between the recipes as provided and the actual diets as prepared has long been considered a disadvantage to the use of home-prepared diets (as well as the use of commercial diets formulated to meet AAFCO nutrient profiles based on information contained in the recipe rather than through analysis of the finished product). These differences are compounded by vague recommendations regarding supplement-type products in many recipes. For example, the use of 1 brand of canine multivitamin instead of another could have dramatic effects on the final composition of a diet.

Additionally, there is the issue of the lowest threshold for intake of various nutrients and the interval before clinical signs develop. It is possible that feeding a diet that does not meet AAFCO recommendations or NRC RAs for various nutrients may not cause overt clinical disease. Although some nutrient deficiencies (eg, thiamine or taurine) can be evident in adult animals after a food deficient in those nutrients is fed for weeks to months, it can be months to years before clinical signs are evident for other nutrient deficiencies (eg, calcium in an adult animal). The status of many nutrients is not easily determined, and the first clinical signs of deficiency may be catastrophic (calcium deficiency resulting in osteopenia and pathological fractures or taurine deficiency resulting in dilated cardiomyopathy). Currently, the authors are aware of no evidence to suggest that cancer patients have nutrient needs that differ dramatically from maintenance requirements. Many dog owners change to home-prepared diets because of an overall perception that they are healthier than commercial diets, rather than because they provide specific nutrient profiles. Thus, it appears appropriate that home-prepared diets be formulated to meet nutrient guidelines similar to those of commercial products.

Conclusions

Recipes of home-prepared diets intended for dogs with cancer are invariably nutritionally inadequate on the basis of AAFCO nutrient profiles and NRC RAs for adult maintenance. Commonly recommended commercial diets and recipes for home-prepared diets are typically low in carbohydrate and high in fat, although there is wide variation among diets. Veterinarians have a responsibility to counsel clients on the potential risk of feeding home-prepared diets formulated from recipes found online or in books or magazines and should encourage clients to use the services of a board-certified veterinary nutritionist who has experience in formulating home-prepared diets to ensure optimal nutrition. It is also important for veterinarians and clients to recognize that many of the nutritional strategies currently advocated by both veterinarians and nonveterinarian sources for pets with cancer have minimal or no experimental data to substantiate their use.

a. Evaluator, DVM Consulting Inc, Davis, Calif.
b. USDA National Nutrient Database for Standard Reference: Release 23, Nutrient Data Laboratory, Beltsville Human Nutrition Research Center, Beltsville, Mass.
c. Rx Essentials for Dogs, Rx Vitamins for Pets, Elmsford, NY.
d. Centrum original, Pfizer Consumer Healthcare, Kings Mountain, NC.
e. Kids Centrum Chewables, Pfizer Consumer Healthcare, Kings Mountain, NC.
f. Hill's Prescription Diet n/d, Hills Pet Nutrition Inc, Topeka, Kan.
g. Microsoft Excel 2010, Microsoft Corp, Redmond, Wash.
h. Minitab, version 16, Minitab Inc, State College, Pa.

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16. US FDA Center for Veterinary Medicine. Manufacture and labeling of raw meat foods for companion and captive noncompanion carnivores and omnivores. Available at: www.fda.gov/downloads/animalveterinary/guidancecomplianceenforcement/guidanceforindustry/ucm052662.pdf. Accessed Jul 23, 2012.
17. Medline Plus. Safe eating during cancer treatment. Available at: www.nlm.nih.gov/medlineplus/ency/patientinstructions/000061.htm. Accessed Jul 23, 2012.

New Veterinary Biologic Products

Product name	Species and indications for use	Route of administration	Remarks
Foot and Mouth Disease Virus Vaccine, Live Adenovirus Vector (Antelope Valley Bios, Inc, Lic No. 419)	For vaccination of cattle 3 months of age or older as an aid in the prevention of foot and mouth disease	IM	This vaccine may only be used as part of an official USDA animal disease control program. Conditional license issued 5/31/12
Swine Influenza Vaccine, RNA (Harrisvaccines, Inc, Ames, Iowa, US Vet Lic No. 592)	For vaccination of healthy pigs 3 weeks of age or older as an aid in the prevention of disease caused by Swine Influenza Virus H3N2. Efficacy was demonstrated in pigs that received 2 doses of vaccine and were challenged 5 weeks after the second vaccination with Swine Influenza Virus H3N2	IM	USDA licensed 9/18/12