German Journal of Veterinary Research
eISSN:2703-1322

Review article

Nutritional risks and consequences of meat-only diets for dogs and cats

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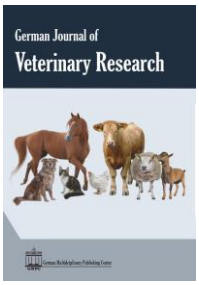

Article History:
Received: 28-Dec-2023
Accepted: 05-Apr-2024
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Abstract

Suitable nutrition is one of the most significant issues that always needs to be considered in the health maintenance of living beings. One of the misconceptions of many societies is the exclusive feeding of meat to cats and dogs. Dogs and cats are carnivorous animals; more specifically, cats are strict or true carnivores, while dogs are omnivores. Although cats are true carnivores, an exclusive diet of meat will not cover their needs. Wholly meat-based diets might be rich in many nutrients and minerals, but they are poor in digestible carbohydrates and fiber. Lack of carbohydrates can cause gastrointestinal problems and diarrhea. Also, due to hypovitaminosis A and D caused by such diets, skeletal diseases can be one of the serious consequences. High dietary phosphate > 11.8g in dry matter (DM) reduces renal phosphate reabsorption and increases vulnerability to chronic kidney disease. As phosphate excretion and reduction of calcium reabsorption continue, bone decomposition, symptoms of osteoporosis, and secondary hyperparathyroidism occur. In wholly meat-based canine diets, a lack of carbohydrates compels the animal to use protein in the gluconeogenesis process to produce glucose. As a result, the body goes through protein deficiency and its side effects. To maintain digestive system health and prevent diarrhea, the diet must include soluble fiber. Also, the presence of carbohydrates and fats is essential. Preserving the correct calcium-to-phosphorus ratio (Ca: P) can be solved by adding carbohydrates or using meats with a lower phosphorus content.

Keywords: Exclusive meat diet, Rickets, Chronic kidney diseases, Hyperparathyroidism

Citation: Tazerji, S. S., Elahinia, A., Akhtardanesh, B., Kabir, F., Vazir, B., Duarte, P. M., Hajipour, P., Rehman, A., Ilyas, M. F., Hassanzadeh, S., Gharieb, R. 2024. Nutritional risks and consequences of meat-only diets for dogs and cats. Ger. J. Vet. Res. 4 (1): 62-76. https://doi.org/10.51585/gjvr.2024.1.0076

Introduction

Both dogs and cats are carnivores; more specifically, dogs are omnivores, and cats are strict or true carnivores (Fascetti and Delaney, 2012). Despite being obligate carnivores, dogs' dietary needs have changed somewhat as a result of domestication. Wolves are the ancestors of dogs. Dogs are now able to consume a wider range of items, such as meat, grains, vegetables, and fruits, as part of an omnivorous diet. Genomes of modern dogs exhibit signs of adaptation to a starch-rich diet, demonstrating their capacity to process and assimilate plant-based nutrients.

Dogs can survive on a balanced omnivorous diet, but it's important to remember that they still need a sizable number of animal-derived proteins for good health (Axelsson et al., 2013). Cats can strictly consume proteins produced from animals because they are obligate carnivores. Some enzymes required for the effective digestion of plant-based nutrients, notably carbohydrates, are absent in cats, in contrast to dogs. Small mammals, birds, and other animal prey make up the majority of their natural diet in the wild. Particular dietary requirements apply to cats, such as the need for taurine, an important amino acid

mostly present in animal tissues. Cats who consume insufficient amounts of taurine may experience serious health problems, such as heart difficulties and blindness. The rigorous carnivorous nature of cats is highlighted by their dietary requirements, underscoring the significance of feeding them a diet high in premium animal proteins (Morris, 2002). Even though meat is the main source of food in these two groups of animals, the exclusive consumption of meat is not a good diet capable of alleviating their maintenance and growth needs. Although all meat diets might have various nutrient compositions, they are similar in their lack of digestible carbohydrates and fiber. Hypovitaminosis A and D may result from the absence of liver from an exclusive meat diet. Diets containing boneless meat pieces can cause calcium deficiency. Consumption of thyroid gland tissues may cause thyroid hormone alterations (Beynen, 2015).

Meat-based diets for cats and dogs can lead to unbalanced nutrition, lack of fiber, obesity, urinary tract health issues, nutrient toxicity, transmission of zoonotic diseases, dental issues, and environmental impact (German, 2006). Meat-based diets may lack essential nutrients like vitamins and minerals, leading to digestive issues like constipation. Overconsumption of meat without proper portion control can contribute to obesity and related health issues. Inadequate fiber can cause digestive issues, while excessive meat consumption can lead to nutrient toxicity (Bauer, 2007). Raw or undercooked meat can transmit zoonotic diseases to pets and humans (Fletcher, 2016). Dental issues may arise from a lack of dental health support in meat-based diets. Mass production of meat for pet food can contribute to environmental issues. Consultation with a veterinarian is essential for pet health and well-being (Okin, 2017). Companion animal owners are increasingly concerned about the link between degenerative health conditions, farm animal welfare problems, environmental degradation, and animal farming. They are considering vegetarian diets for themselves and their companion animals. However, studies have shown that vegetarian diets may be healthy, even for high-exercising cats and dogs. However, these diets must be nutritionally complete and balanced, and owners should monitor urinary acidity and correct it with appropriate dietary additives (Knight and Leitsberger, 2016). Based on the presented data, the risks and issues of all-meat diets will be discussed in this article.

Materials and Methods

Subject-related electronic literature databases were searched without time limits to identify eligible publications reporting relevant factors on the diet of dogs and cats. Keywords related to "diet", "dog," and "cat" were combined with different related keywords. Forward and backward tracking was performed with Google Scholar, Scopus, and Web of Science (WOS) computerized databases to ensure that the search strategy was structured. The Boolean operators “OR” and “*” for single characters were employed to combine search terms. The “AND” Boolean operator was used to combine the keyword into a search string. As English is the current international language of academic publication and considering the review’s global focus, we limited the language of the search terms to English. EndNote library was used to remove duplicate records and record their numbers. There has been a lot of research conducted regarding the long-term impacts of various diets on the health of dogs and cats. Here, we will examine how different diets affect these animals' health, stressing the value of a diet that is both balanced and full of nutrients.

Biological requirements of companion animal diets

Domestic cats and dogs belong to the Carnivora order and have evolved to subsist on captured prey animals primarily. However, domesticated dogs, which were partially dependent on human food scraps, have evolved to metabolize carbohydrates and subsist on a diet lower in protein (Buff et al., 2014). Domesticated cats, on the other hand, have evolved to hunt and kill wild animals and have a macronutrient profile similar to wildcats (Armstrong et al., 2010). To thrive in modern, domesticated environments, dogs and cats need diets that are palatable, bioavailable, and nutritionally complete. Vegan diets, which are available as supplements, may not meet these requirements (Axelsson et al., 2013).

The National Research Council provides nutrient recommendations for dogs and cats, which are based on the Association of American Feed Control Official's (AAFCO) nutrient profiles (Council, 2006). AAFCO provides guidelines for developing and implementing uniform laws, regulations, standards, and enforcement policies (AAFCO, 2014). Other countries and regions have developed their own nutritional guidelines based on country-specific legislation and AAFCO guidelines (Baldwin et al., 2010).

Companion animal diets may be labeled as nutritionally complete and balanced, with two recognized methods: formulating the diet to meet AAFCO nutrient profiles or conducting a feeding trial using AAFCO-approved protocols (AAFCO, 2014).

For cats and dogs to be healthy and live long lives, they need to eat a diet rich in nutrients and well-balanced. Veterinarians and pet owners can customize diets for carnivorous and omnivorous animals to meet their specific nutritional requirements and promote healthy development, maintenance, and general well-being. It's essential for the general health and well-being of cats and dogs to make sure they eat a balanced, nutritionally complete diet. To avoid nutritional deficits and support optimum physiological function, it is important to provide for the unique dietary requirements of cats and dogs due to their carnivorous and omnivorous lives. Several factors should be considered by studying the nutritional requirements of dogs and cats. i) *Importance of balance*. Dogs and cats need to have a balance of micronutrients (vitamins and minerals) and macronutrients (proteins, fats, and carbohydrates). A diet that is out of balance can result in obesity, malnutrition, and deficits in important nutrients, among other health concerns (Michel and Backus, 2023). ii) *Individualized diet*s. Preparing a diet that suits each pet's unique demands requires an understanding of their unique needs. When creating a nutritionally full and balanced diet, factors including age, breed, exercise level, and health state should be taken into account (Di Cerbo et al., 2017). iii) *Dogs-omnivores with carnivorous bias*. Dogs need a significant proportion of animal-derived proteins for good health, even if domestication has led to a more omnivorous diet. Dogs should eat a variety of high-quality protein sources, carbs, lipids, vitamins, and minerals in a balanced diet. Dogs are guaranteed to obtain the vital nutrients required for energy, growth, and maintenance with this well-balanced approach (Case et al., 2010). iv) *Cats - obligate carnivores*. Cats have special dietary needs that correspond to their obligate carnivorous lifestyle. A diet high in animal-derived proteins, especially meat, must provide taurine and other necessary amino acids. The amino acid taurine, which is mostly present in animal tissues, is essential for a number of physiological processes in cats, including heart and visual health (Council, 2006).

Health of omnivorous and carnivorous companion animals

Meat-based diets for companion animals pose significant health risks, including contamination with pathogenic microorganisms and mycotoxins. Major recalls of pet food brands have occurred due to chemical contaminants or misformulations (Marks et al., 2011). Commercial pet food brands may also contain abattoir products considered unfit for human consumption, such as "4-D" meat. Plastic ear tags are not always removed, and old or spoiled supermarket meat may be used without proper packaging. Residues derived from farm or industrial practices can result in pharmacologically active compounds, including ionophore antibiotics, which can be toxic to cardiac and skeletal muscles and peripheral nerves and can cause paralysis or death in dogs and cats (Motarjemi and Lelieveld, 2014). Fish are also commonly used in pet food, but they have not evolved mechanisms to excrete modern oceanic pollutants, and their decomposition rates are faster than terrestrial animals. Other potential hazards include free radicals, trans fatty acids, hormonal residues, chemical preservatives, and degradation of sensitive nutrients due to processing temperatures, pressures, and chemical treatments (Dobson et al., 2008). Meat-based diets for companion animals pose significant health risks as follows: i) *Fat intake*. Cats need to consume a certain amount of fat for vitality, skin health, and the absorption of fat-soluble vitamins. Nonetheless, pancreatitis and obesity can both be exacerbated by extra fat. Healthy levels of fat are essential for energy and coat integrity in dogs, but consuming too much fat can result in obesity and other health problems. ii) *High-protein diets and carbohydrate content.* Eating a high-protein diet consistently over time is essential to keeping obligate carnivores like cats healthy. Sufficient consumption of protein promotes immune system performance, muscular maintenance, and general health. Cats can't use carbohydrates very well; eating a lot of them can lead to long-term obesity and diabetes (Musco et al., no date). High-quality protein sources are essential for dogs' immune systems, muscular growth, and coat health. Dogs may handle modest carbohydrate intake, but a diet overly rich in carbohydrates can eventually cause obesity and metabolic problems (Laflamme, 2008). iii) *Essential nutrients.* Improvements in companion animal nutrition have led to the development of balanced foods, emphasizing product safety and traceability. Cats require taurine, an important amino acid that is mostly found in animal tissues. Prolonged taurine insufficiency can cause major health concerns, such as hear

trouble and blindness. Dogs can get some nutrients from plants more easily, dogs nevertheless need a balanced diet with the right components for long-term health (Bontempo, 2005). iv) *Plant-based diets.* Plant-based pet foods are gaining popularity, but their suitability for dogs and cats remains unclear. A study in Ontario, Canada, analyzed 26 plant-based diets, comparing nutrient measurements to industry standards. Four met recommendations from the Association of American Feed Control Officials and one from the European Pet Food Industry Federation for adult dogs, but none met recommendations for adult cats or growing puppies or kittens. The study suggests manufacturers must improve formulation and manufacturing practices to produce products suitable for both species (Dodd et al., 2021). Cats are obligate carnivores; a diet devoid of plant-based foods is not recommended for their long-term health. It may result in malnutrition, including shortages of vital minerals and amino acids. Dogs may be better suited to plant-based diets than humans, but in the long run, a fully vegetarian or vegan diet may need careful supplementation to cover all nutritional requirements (Laflamme and Hannah, 2013).

Individual variability

Depending on their breed, age, health, and degree of activity, each animal may have specific dietary needs. Long-term health depends on a diet that is customized for each individual. Diabetes, arthritis, and urinary system disorders are just a few of the health concerns that can arise from long-term obesity in cats. Obesity is a widespread problem that can lead to a number of health concerns, such as orthopedic difficulties and shortened lifespans (Linder and Parker, 2016).

The effect of factors such as exercise, age, and individual health conditions on nutritional requirements

Dogs and cats have different dietary needs depending on their age, degree of exercise, and individual health issues. Comprehending and tackling these variables is essential to customize a diet that fulfills each animal's individual requirements. i) *Exercise level.* Physical activity is crucial for cats to maintain a healthy weight and avoid obesity. Very active cats could need more energy, so their food might need to be changed to ensure they get enough calories and minerals. Dogs' nutritional requirements and activity levels are strongly related. Very active dogs, such as working or sporting breeds, can need meals that are higher in protein and energy to keep up with their energy needs (Laflamme, 2005). ii) *Age.* Depending on their stage of life, animals can have various dietary needs. For instance, older pets may need diets that maintain joint health and address age-related changes in metabolism, whereas puppies and kittens have increased energy needs for growth (Larsen and Farcas, 2014). iii) *Individual health conditions*. Special diets may be necessary for pets with certain medical issues, such as diabetes, kidney illness, or allergies. Using the right nutritional therapies to manage these diseases requires veterinary assistance. For example, a diet low in phosphorus may be beneficial for cats suffering from kidney disease (Polzin, 2013). iv) *Weight management.* Maintaining an ideal body weight is essential for general health. Being overweight or obese is a frequent condition that can lead to a number of health difficulties, such as joint problems, diabetes, and a shorter lifespan. Pets who need to gain or lose weight may benefit from specialized weight control meals (German, 2006).

Failure to meet comprehensive nutritional needs by meat, even though it is a vital component

Meat is a great source of protein, vitamins, minerals, and essential amino acids, it is not a significant supply of fiber or carbs, which are vital for many animals to have a balanced diet. Pets, such as dogs and cats, have different nutritional requirements than people. Because they are obligate carnivores, cats have a greater need for nutrients originating from animals, such as proteins and certain vitamins. Because they are omnivores, dogs benefit from eating animal proteins even if they can digest some plant-based diets. Maintaining a lean body condition is a common goal, increasing life quality in dogs and, potentially, in cats. Regular assessments and adjustments are necessary for each species (Marks et al., 2011).

Commercial pet feeds are made with other ingredients that provide these nutrients to overcome the deficiency of carbs and fiber in meat-based diets for pets. In order to satisfy the unique nutritional requirements of cats and dogs, pet food makers carefully craft their products, guaranteeing a balanced combination of proteins, fats, carbs, vitamins, and minerals. A veterinarian's advice can assist in modifying the diet to the specific requirements of the pet. Selecting premium pet food that satisfies the nutritional guidelines established by credible organizations is vital for pet owners (Council, 2006).

Nutritional requirements of cat and dog with the passage of age: Puppies, kittens, and adult animals and tailoring diets for optimal health.

Depending on their life stages—kittens, adults, and aged animals—cats and dogs may have different dietary needs. For optimum health, a diet specific to these phases must be given as follows. i) *Puppies and kittens.* Puppies and kittens require more energy in their early years of life to grow and thrive. They require a diet richer in fat, protein, calcium, and phosphorus to promote the growth of their muscles and bones (Council, 2006). A balanced diet is a complex and delicate requirement of macro and micronutrients for optimal development of skeletal, joint, and other body systems, particularly for large breed dogs (Hemmings, 2016). *ii) Adult dogs and cats.* The nutritional requirements of adult animals vary depending on breed, size, and activity level. It's important to have a balanced diet that includes the right amounts of fats, proteins, vitamins, and minerals. Maintaining weight control and regular exercise are essential for good health (Legrand-Defretin, 1994). iii) *Senior dogs and cats.* Older pets may be less active and have altered metabolisms. Senior diets frequently call for higher fiber intake for digestive health, fewer calories to avoid obesity, and joint supplements to improve mobility. The need for routine veterinary examinations to detect and treat age-related problems increases (Taylor, Adams, and Neville, 1995).

Ensuring optimal nutrition for pets involves addressing various challenges that pet owners may encounter. Here are some common challenges and actionable solutions. i) *Obesity and overfeeding*. Obesity is a common nutritional disorder in companion animals, resulting from excessive dietary intake or inadequate energy utilization. Factors such as genetics, physical activity, and diet can predispose individuals to obesity. Obesity can lead to various health issues, including orthopedic disease, diabetes, and cardiovascular diseases. Therapeutic options include dietary management and physical activity. Although no pharmaceutical compounds are yet licensed for weight loss, dietary therapy is the foundation, and awareness of obesity as a serious medical concern is needed (German, 2006). Actionable Solutions: To prevent overfeeding, measure daily food portions, implement a consistent exercise routine, and opt for low-calorie treats or use a portion of the daily food ration as treats (Laflamme, 2006). ii) *Age-related nutritional needs*. Cats and dogs have varying nutritional needs based on age. Kittens require higher protein for muscle development and more calories for growth and energy. Adult cats need protein for muscle mass and overall health. Weight management is crucial as cats age, and some adult cat foods support dental health. Senior cats need protein for lean muscle mass and joint health, and some senior formulas may include fiber for digestive health. Dogs need protein for growth and development, calcium and phosphorus for bone development, and DHA for brain and eye development. A balanced diet is essential for optimal health. Veterinarian consultation is recommended for individual pet needs (Laflamme, 2005). *Actionable solutions:* Transition to age-appropriate commercial diets for puppies, adults, or seniors, and schedule regular veterinary check-ups to assess changing nutritional needs (Laflamme, 2005). iii) *Food allergies and sensitivities*. Adverse reactions to food can affect various systems, with most reactions affecting the skin, gastrointestinal tract, respiratory tract, and central nervous system. In dogs and cats, food allergy and intolerance are rare, but their incidence is difficult to establish. Diagnosis is difficult due to the lack of a single test. Diagnosis is based on dietary investigation, with elimination diets for dogs and cats being effective. Improvement in clinical signs suggests food allergy (Wills and Harvey, 1994). *Actionable solutions*: Consider hypoallergenic or limited ingredient diets, or work with a veterinarian to conduct elimination diets to identify specific allergens. iv) *Dental health*. Dental health may affect an animal's capacity to consume and digest food. Specialized diets may be recommended for the treatment of oral health disorders such as dental tartar and gingivitis (Moynihan and Petersen, 2004). Actionable solutions: Using specially formulated dental diets and providing dental chews or toys can help maintain oral hygiene and promote oral health. *v) Specialized diets for health conditions*. Diet for pet health promotion and disease management has gained attention in recent years. Veterinarian health professionals face the challenge of staying current with research on clinical nutrition and understanding pet owners' feeding practices. With the growing use of the World Wide Web, they must navigate a gray area in medicine, ranging from conventional practices to alternative therapies like diet manipulation and dietary supplements (Michel, 2006).

Actionable solutions: A balanced, tailored diet is crucial for pet well-being. It requires informed decision-making, regular consultations, and a commitment to nutrition and lifestyle adjustments.

Food deficiencies and consequences

Explicitly linking nutritional deficiencies to specific health outcomes in pets is crucial for their overall well-being. For instance, protein deficiency can lead to muscle wasting, weakened immunity, and poor growth in puppies and kittens (Council, 2006). Calcium and phosphorus imbalance can result in bone and joint disorders, such as rickets in growing animals. Omega-3 fatty acid deficiency can cause impaired brain and vision development in puppies and kittens (Bauer, 2007). Obesity and overfeeding can increase the risk of diabetes, cardiovascular issues, and joint problems in adult and senior pets (Laflamme, 2006). Dental health neglect can lead to periodontal disease, tooth decay, and gingivitis (Gorrel, 1998). Vitamin and mineral deficiencies in homemade diets can lead to nutritional imbalances, leading to various health issues. Food allergies and sensitivities can cause gastrointestinal distress, skin issues, and allergic reactions. Raw meat diets can increase the risk of infectious diseases, nutrient imbalances, and potential harm to pets and humans. Therefore, it is essential to have a balanced and well-formulated diet for optimal pet health and to seek informed decision-making and veterinary guidance in addressing specific nutritional needs (Freeman et al., 2013). In the following, the risks and issues of the all-meat diet are discussed.

Risk of rickets

The ability to produce vitamin D3 biosynthesize (cholecalciferol) in the skin using UV-B (ultraviolet-B) exists in amphibians, omnivores, birds, herbivores, and reptiles, but cats and dogs need foods that contain an adequate amount of vitamin D in their diet (How, Hazewinkel and Mol, 1994; Beynen, 2015). Food sources high in vitamin D include fish, animal fats, and visceral organs such as the liver (Lamberg-Allardt, 2006). Vegetables, low-fat white meats, and porcine meat have very low levels of vitamin D (Fascetti and Delaney, 2012). Sole-source nutrition with low-fat meats and chicken may increase skeletal disease, hypovitaminosis D, and rickets in large dog and cat breeds (Beynen, 2015). On the other hand, using raw liver and fish on a daily basis and taking supplements with high levels of cod liver oil will cause hypervitaminosis A in cats (Bennett, 1976) and increase the possibility of anorexia, dull hair coat, new bone formation, especially between the cervical vertebrae, and stiffness and immobility of the joints in both cats and dogs (Wills and Simpson, 1994; Fascetti and Delaney, 2012). Hypervitaminosis A has been reported in cats fed pork liver diets (Freeman et al., 2013).

Literature reviews revealed that phosphate supplements and high-phosphate diets could increase the risk of osteoporosis in different animal species (Krook and Lowe, 1964; Joyce et al., 1971; Draper et al., 1972). High-phosphate diets, such as poultry and beef, will trigger calciuria along with excessive excretion of phosphate through the kidneys. As the kidneys retain phosphorus, the parathyroid gland is stimulated to release parathyroid hormone (PTH) to increase renal phosphorus excretion and prevent calciuria. However, PTH also stimulates the release of phosphorus from bones, which exacerbates hyperphosphatemia. In addition, calcitriol deficiency occurs secondary to decreased renal production of 1-α-hydroxylase and hyperphosphatemia. This ultimately leads to calcium deficiency and increased PTH production (Jowsey, Reiss, and Canterbury, 2009). As this situation progresses, nutritional secondary hyperparathyroidism develops, ultimately causing rickets (Laflamme and Jowsey, 1972; Barber and Elliott, 1998). Jowsey J. et al. showed that an increase in phosphorus levels in a dog's meal significantly increases urinary excretion of phosphorus and slightly increases urinary calcium, but no changes in fecal calcium or phosphorus levels were noted (Jowsey, Reiss, and Canterbury, 2009).

Dogs and cats fed predominantly meat—or offal-based rations without vitamin D supplements develop fibrous osteodystrophy rather than rickets due to nutritional secondary hyperparathyroidism. Naturally occurring rickets are rare in cats. Cats experimentally fed a diet deficient in vitamin D develop clinical signs of rickets after 4 to 5 months. The diagnosis of rickets is based on radiographic changes and elevated serum alkaline phosphatase levels, which are not specific to rickets.

Chronic kidney diseases

The maximum ratio of phosphate to calcium in dog and cat diets should be 1:1, and the risk of bone problems and rickets increases with phosphate level elevation (Jowsey, Reiss, and Canterbury, 2009). High-protein diets such as meat can cause chronic kidney disease in elderly dogs (Beynen, 2015). One of the most common regulatory disorders in chronic kidney disease is phosphate retention. This condition comes about secondary to a decrease in glomerular phosphorus

filtration. Phosphate retention and hyperphosphatemia occur early in chronic kidney disease. Hyperphosphatemia plays important roles in the induction and progression of renal secondary hyperparathyroidism, hypocalcemia, renal osteodystrophy, and relative or absolute 1,25- dihydroxy vitamin D deficiency (Nagode and Chew, 1992; Barber and Elliott, 1998).

Protein deficiency

The lack of glucose, which is vital for brain function, in dogs that consume a diet exclusively composed of meat may be compensated by a process called gluconeogenesis, which produces glucose from precursors other than carbohydrates. These precursors include certain amino acids, and the process may lead to protein deficiency. However, disturbing the protein balance in the diet causes kidney problems and diarrhea in dogs, especially in breeding dogs (Council, 2006).

Risk of diarrhea

Lack of fiber in an all-meat diet is a risk factor for diarrhea. Insoluble fiber must be added to fiber-free diets (Morgan et al., 1951; Wichert et al., 2002). For example, when puppies aged less than 17 weeks are fed a diet including chicken necks that are boiled and ground as multivitamin supplementation, they suffer from diarrhea (Resnick, 1978). In one study, the feces of puppies turned foul-smelling and dark following a diet of commercially-produced beef chunks and meat by-products (as stated on the label) (Goddard et al., 1970).

Raw meat-based diet problems

Nowadays, it is not uncommon among pet owners to feed their pets raw meat-based diets. Nevertheless, veterinarian recommendations are still sought by those who care for their pets' diets (Schlesinger and Joffe, 2011). Raw food might contain bones from poultry, fish, or mammals, internal organs, and skeletal muscles (Freeman et al., 2013). Raw meat and internal organs can be easily contaminated during slaughter, processing, or transportation and frequently test positive for microbial pathogens. One investigation revealed that approximately half of the raw diets might contain lower iodine, zinc, and copper levels than the recommended allowance for dogs in addition to hypovitaminosis A or Ca: P ratio disturbance (Dillitzer, Becker, and Kienzle, 2011). Zoonotic pathogens have been shown to spread, both through contaminated raw meat products and through the feces of raw meat-fed pets, and this creates real dangers for owners during food preparation or close contact with pets (Freeman and Michel, 2001). RMBDs can cause health risks such as safety and nutritional concerns (Freeman et al., 2013). A study in the US in 2001 examined two commercial and three home-prepared RMBDs. All commercial and home-prepared RMBDs caused nutritional imbalances with hazardous adverse effects on the health of animals. The imbalances can be divided into three major issues, including hypervitaminosis D (nearly twice the maximum AAFCO vitamin D concentration), hypovitaminosis A and E (vitamin A and E levels below the minimum measurable value), and the calcium-to-phosphorus ratio of 0.20 (Freeman and Michel, 2001). Another example is nutritional secondary hyperthyroidism and thyrotoxicosis and vitamin D-dependent rickets type I caused by nutritionally unbalanced RMBDs (Taylor et al., 2009; Broome et al., 2015).

Secondary hyperparathyroidism

Nutritional secondary hyperparathyroidism is the most frequently encountered nutritional bone disorder. This is more significant in dogs, but it can also occur in kittens, especially those of the Siamese breed, and is often linked to diets high in meat (Bennett, 1976).

In one study, nutritional secondary hyperparathyroidism was reported in five German shepherd puppies between 66 and 174 days old with bone deformity. Histopathologically, all the puppies showed moderate to marked fibrous osteodystrophy. These puppies were fed a diet consisting of 80% steamed rice and 20% raw meat, which was high in phosphorus and caused nutritional secondary hyperparathyroidism (Kawaguchi et al., 1993).

Severe metabolic, orthopedic, and neurological anomalies were reported in a dog suspected of nutritional secondary hyperparathyroidism and D-dependent rickets type 1 caused by its homemade meat-based diet. Planning nutrient profiles according to the nutritional needs of patients and correct assessment of diet can prevent unintentional malnutrition (Wills and Simpson, 1994).

Exogenous thyrotoxicosis

Exogenous thyrotoxicosis in dogs was reported in 14 dogs consuming all-meat commercial diets containing excessive thyroid tissues in a case-control study. Dogs showed symptoms of polydipsia, polyuria, and weight loss. Thyrotoxicosis was confirmed by the detection of increased thyroxine concentration in food compared with the

control diet (1.52 vs. 0.38 µg thyroxine/g), which resulted in increased serum thyroxine concentrations (median, 8.8 µg/dL; range, 4.65 to 17.4 µg/dL) and decreased thyroid gland radionuclides (thyroid scintigraphy) in affected dogs. However, symptoms and thyroid levels were resolved four weeks after discontinuing the food (Broome et al., 2015).

Risk of infectious diseases

Veterinary and public health groups, such as the FDA (US Food and Drug Administration), the WSAVA (World Small Animal Veterinary Association), and the CDC (Centers for Disease Control and Prevention), have issued notices prohibiting dogs and cats from eating raw meat (Hiney et al., 2021). A large number of potential pathogens have been discovered in raw meat. *Salmonella* species account for most infections among owners and their animal companions (LeJeune and Hancock, 2001; KuKanich, 2011). Also, *Salmonella spp.* and other pathogens have been found in commercial and homemade RMBDs, according to several reports. (Joffe and Schlesinger, 2002; Weese, Rousseau and Arroyo, 2005; Finley et al., 2008; Lenz et al., 2009; Selmi et al., 2011). Contamination with *Salmonella spp.* has been reported in about 20% to 48% of commercial RMBDs. Another study indicated that the prevalence of *Salmonella spp.* ranges from 7 to 20% of raw pet foods (Davies, Lawes, and Wales, 2019). Cattle, swine, and fowl normally harbor various *Salmonella* species without displaying any visible clinical indications, so it is particularly simple to contaminate raw food during the production process.

In a recent study, 166 commercial RMBD samples were used to estimate *Salmonella spp.* prevalence. As a result, 18 -*Salmonella* -serotypes showed resistance to 12 of the 16 tested antimicrobials (Weese, Rousseau, and Arroyo, 2005; Finley et al., 2008). Contamination of commercial dry extruded foods is also possible. These foods might become contaminated by *Salmonella spp.* and other pathogens. Since all pathogens are not destroyed by freezing and freeze drying, homemade and commercial RMBDs are at risk of contamination with these pathogens (Freeman et al., 2013). A recent Canadian study estimated that the prevalence of *Salmonella spp.* in canine RMBDs is higher than in raw food diets containing chicken. This study showed that *Salmonella* prevalence is approximately 21% higher than a raw food diet containing chicken. There have been many reports of raw food recalls due to *Salmonella* infection in recent years; one instance was the recall of frozen cat food in the USA; however, the prevalence of *Salmonella* in dry foods has decreased. Much of the infection of pets and their environment and risks to public health come from raw food (Giacometti et al., 2017).

RMBD infection has also been evaluated considering other pathogens and bacteria as well (Freeman and Michel, 2001; Strohmeyer et al., 2006). *Escherichia coli* RMBD contamination has been studied in two studies. In one of the studies (Schlesinger and Joffe, 2011), 1 out of 5 tested RMBDs (both home-prepared and commercial diets) was revealed to have *E. coli* O157:H7 contamination. Commercial raw pet meals had a higher incidence of *E. coli*-positive samples than commercially processed feeds (Strohmeyer et al., 2006; Freeman et al., 2013). Contamination of commercial RMBDs with *Clostridium spp.* was reported in another investigation (Weese, Rousseau, and Arroyo, 2005). In this study, the isolation rate of spore-forming bacteria was 16% when measured by ordinary methods. This rate increased to 100% by enrichment methods, with *Clostridium perfringens* identified in 20% of the examined samples.

Contamination of RMBDs with *Campylobacter jejuni* and enterocolitis-causing bacteria has been reported in the case series (Freeman and Michel, 2001). Dogs and cats are known as asymptomatic carriers for *Campylobacter spp.* and, particularly, *C. jejuni, C. upsaliensis,* and *C. helveticus* (Fredriksson-Ahomaa et al., 2017). Raw chicken meat is the major source of campylobacter infection, which is most typically detected in dog and cat feces (Acke, 2018; Abdelmageed et al., 2021). *Brucella suis* causes brucellosis in feral pigs, but dogs that consume wild pig meat exert clinical orthopedic and reproductive symptoms (Mor et al., 2016). *B. suis* is also found in frozen hare meat, which is used for raw pet diets (Frost, 2017). 16% of typically frozen raw cat and dog meals marketed in the United States and 54% of frozen raw pet food sold in the Netherlands contained *Listeria monocytogenes* (Nemser et al., 2014). *Yersinia enterocolitica* can withstand freezing and thawing (Toora et al., 1992), and it's found in game meat, pig offal, and raw pork (Bucher et al., 2008), and it has the potential to infect dogs. The existence of other bacterial organisms that may be pathogenic has been detected in uncooked pet food (species of *Clostridium* and *Staphylococcus aureus*). Other hazards come from the possibility of illness originating from source cattle (*Burkholderia* species, *Bacillus anthracis,* and *Bacillus cereus*), particularly when the pet feed is consumed after sitting at room

temperature (LeJeune and Hancock, 2001; Weese, Rousseau, and Arroyo, 2005; Towell, 2008).

Non-bacterial pathogens previously reported in RMBDs include several helminths and protozoa and constitute potential pathogenic risks. These include *Trichinella* species, *Taenia ovis*, *Taenia hydatigena*, *Echinococcus multilocularis*, *Echinococcus granulosus*, *Giardia*, *Cryptosporidium parvum*, *Isospora species*, *Toxoplasma gondii*, *Sarcocystis species*, and *Neosporum caninum* (LeJeune and Hancock, 2001; Towell, 2008). *Toxoplasma gondii* infection has been globally reported in pets fed raw beef, chicken, and pork meat (Smielewska-Loś, Rypuła and Pacoń, 2002; Lopes, Cardoso and Rodrigues, 2008; Lenz et al., 2009; Taylor et al., 2009), and *Echinococcus multilocularis* infection (Dubey et al., 2005) has been reported within limited geographical areas in dogs fed raw wild animal viscera (Antolová et al., 2009). In a study that compares the practices reported by dog and cat caregivers and investigates whether cleaning method, feed type, or bowl material affects the microbiological contamination of dog food bowls, *Enterobacteriaceae* counts were higher in bowls washed by hand vs. dishwasher, whereas no differences were found between hand washing vs. dry wiping. *Salmonella* spp., *Campylobacter* spp., or *E. coli* VTEC contaminations were not detected (Raspa et al., 2023).

Microbiota, metabolomics, and proteomics changes

Microbiota

It has been illustrated that intestinal microbiota have a significant role in both animal and human health. Omnivorous rodents and humans now provide a model for the assessment of changes in the microbiota of pet feces. Nevertheless, there is comparatively little information on how microbiota affects the health of carnivorous pets. It is necessary to combine changes in phenotypic data and microbe constitution, such as physiological factors and dietary data (e.g., metabolite manufacture and nutrient digestibility), to explain how optimum pet nutrition is affected by microbial population changes (Deng and Swanson, 2015). In another study, dogs with conventional feeding and BARF were tested. Diet groups demonstrated no significant difference in alpha-diversity measures. A significant difference between the groups was detected in beta diversity in similarity scans (ANOSIM) ($P < 0.01$). Linear distinguishing analysis effect size (LefSe) showed that dogs fed conventionally demonstrated higher *Lachnospiraceae*, *Ruminococcaceae*, *Erysipelotrichaceae*, and *Clostridiaceae,* but the BARF group showed higher levels of *Clostridium*, *Fusobacterium*, *Enterobacteriaceae,* and *Lactobacillales*. qPCR studies of the BARF group showed dysbiosis index enlargement and much greater profusion of *Clostridium (C.) perfringens* and *Escherichia coli* (*E. coli)* (Viegas et al., 2020). Another study showed a higher likelihood of positive test results for *Salmonella spp.* and *C. perfringens* in feces sample microbiological analysis among animals feeding on RMBD. This includes multiresistant serovars and strains that have been reported in humans and have the potential to contribute to infections. Our study also showed that *C. difficile* isolates of ribotypes/sequence types that have been known to cause disease in humans may be preserved by the animals mentioned above. Thus, it is imperative to take into account the dangers RMBDs cause for both pets and their owners. Moreover, the results of microbiological tests point to the importance of following hygiene protocols when handling pet feces if they are fed RMBDs (Viegas et al., 2020).

Metabolomics

Clustering of diet groups was observed in metabolomics data PCA (principal component analysis). Random investigation and analysis revealed differences in the amounts of some components, such as GABA (4-aminobutyric acid) and GBH (4-hydroxybutyric acid), in the BARF group. Remarkable differences in different metabolites were observed in univariate statistics between diet groups. However, the significance was lost with the regulation of data for multiple comparisons. Fecal bile acid concentrations were not significantly different; dogs fed conventionally had lower fecal cholesterol concentrations than the BARF group (Schmidt et al., 2018). The metabolome was profoundly affected by the BARF diet; even though changes in bile acids of the primary and secondary kinds were insignificant, there were increased levels of cholesterol in the BARF dog feces. There was a difference in many metabolites like GHB, GABA, and isomaltose between the groups, as observed in heat maps, PCoA plots, and random further analysis; however, after univariate statistics were used to adjust them, the difference became insignificant. The results show that differences in metabolome and microbiome macronutrient compositions in the feces are noticeable (Schmidt et al., 2018).

Proteomics

Although fecal weight and VFA levels were lower, apparent protein and energy digestibility were

higher in meat-fed dogs. Diet significantly affected 27 microbial families and 53 subfamilies in the feces. To be more specific, dogs fed a meat-based diet showed a lower profusion of *Faecalibacterium*, *Peptostreptococus*, *Prevote-lla,* and *Bacteroides,* but they had higher levels of *Clostridium, Lactobacillus,* and *Fusobacterium,* (Bermingham et al., 2017). It has been said that as cooking destroys necessary enzymes, one of the benefits of RMBDs is digestive improvement. Improved digestion in animals on RMBDs has been demonstrated in studies; however, most cats and dogs do not need to receive enzymes from external sources. According to one study, the crude protein in RMBDs has been found to be remarkably more digestible, but this is not the case for dry matter, energy, or fat (Vester et al., 2010). Domestic cats fed an RMBD in one study showed significantly higher macronutrient digestibility (4.6% to 14.3% higher) and energy (8.0% higher) compared to those eating an extruded dry diet. The observed mild improvement in RMBD digestibility compared with the extruded dry diet may be related to the beneficial effects of the RMBD, but also the general negative effects of extruded diets or the specific negative effects of the extruded diet tested in that study (Lamberg-Allardt, 2006). Despite the negative effects of conventional heat processing on proteins in animal tissue, through denaturing antinutritional factors, heat can make some plant proteins more bioavailable. For instance, the chymotrypsin and trypsin inhibitors in legumes can inhibit the digestion of proteins and make them less bioavailable, but the denaturing of these inhibitors through heat processing raises the bioavailability of the proteins (Freeman et al., 2013). According to another study, three groups of dogs were tested: MD (raw meat-based diet), RD (commercial extruded diet), and CD (continued to feed with RD diet). The MD treatment significantly ($P < 0.05$) lowered the fecal score and increased the lactic acid concentration in the feces compared with the RD treatment ($P < 0.01$). A numerical increment, even though not significant ($P = 0.081$), was also observed for the proportion of butyrate in MD treatment. In comparison with the RD treatment, acetic acid was lower ($P < 0.05$) for MD and CD treatments, although for CD, the concentration was closer to RD. No significant changes were observed in the molar content and proportion of other SCFAs (Sandri et al., 2017).

Accidental injuries

Since RMBDs might contain bones, they can cause tooth fractures and gastrointestinal injury. Perforation or obstruction of the colon, small intestine, stomach, or esophagus might be possible because of bones. It has been found that 30% to 80% of esophageal foreign bodies in dogs and cats were bones, but no study has compared how often obstruction is caused by cooked versus raw bones. One study reported feline pancreatitis in 10 cats that were fed a home-prepared diet of cooked or raw oily fish and cooked pig brain. Diets high in unsaturated fatty acids relative to vitamin E are thought to be the cause of pancreatitis. Bone and raw food (BARF) diet has been presented as a cause of nutritional osteodystrophy in young puppies (Freeman et al., 2013).

Clinical and nutritional recommendations for a paradigm shift in all-meat diet regimes

Diarrhea prevention

The lack of fiber in an all-meat diet may aggravate diarrhea. In general, three types of fiber (soluble, insoluble, and mixed fiber) are used in dog food, but diarrhea is mostly treated by insoluble and mixed fiber fruits and gums, which are common sources of soluble fiber that could be used in pet foods to improve the texture of canned food. Insoluble fiber generally originates from grain added in cellulose form and increases fecal bulk. However, fiber from whole grains is typically a “mix” of both soluble and insoluble fibers. “Mixed” fiber with mostly soluble fiber characteristics is mostly used for supplementation. Psyllium fiber is the best example of mixed fiber. Pumpkin pie can be used at a lower dose and titrated up as needed (Fascetti and Delaney, 2012).

Rickets prevention

To get sufficient Vitamin D, pets have to use food sources of vitamin D, including fish, animal fats, and offal, such as liver (Lamberg-Allardt, 2006). However, vegetarian food and low-fat meats, white meat such as poultry, and red meat such as pork have very low levels of vitamin D (Fascetti and Delaney, 2012). Ca deficiency and/or inappropriate Ca:P ratio is noticeable in many homemade diets. To solve this problem, the meat of an animal such as lamb, horse, fish, turkey, or a legume protein (e.g., bean) as the protein source and potato, sweet potato, rice, or pasta as the carbohydrate source should be cooked, mixed in the correct ratios, and then frozen in meal-sized sealable plastic bags (Hynd, 2019).

Protein deficiency prevention

Gluconeogenesis from non-carbohydrate precursors such as protein is a result of a lack of carbohydrates in the diet. Thus, the diet should contain digestible carbohydrates. Digestible carbohydrates have protein-sparing effects and supply energy to the body. Animals eat to provide energy for their bodies, so before the body employs the energy-rich nutrients for other functions, it makes sure the necessary energy is supplied. The consumption of sufficient carbohydrates will protect proteins from being treated as energy supplies rather than material for tissue growth and repair. The body is able to store the extra glucose as glycogen. However, a large number of carbohydrates can be converted to fat by the body as a source of energy. Therefore, excessive consumption of dietary carbohydrates can lead to obesity. Although dietary fiber does not have a significant role in a balanced diet, it is beneficial to include some in the diet (Case et al., 2010). Cooked white rice, potato, and pasta can be counted as suitable carbohydrate sources (Fascetti and Delaney, 2012; Hynd, 2019).

Mature cats and dogs need balanced nutrition for normal health and growth, as do all other animals. Nutrients have important roles because of their specific functions in optimal health tissue maintenance and growth. The body may not be able to synthesize some nutrients. Thus, adequate vital nutrients should be included in the diet to meet the body's needs. To supply adult dog maintenance, usually, 24% protein, 38% carbohydrate, and 38% fat are needed. However, a growing dog's diet should contain 27% protein, 32% carbohydrate, and 41% fat (Case et al., 2010). Primary nutrient contribution is presented in Table 1 (Case et al., 2010).

Table 1. Primary nutrient contribution (Case et al., 2010).

Protein	Carbohydrate	Fat	Dietary Fiber
Beef	Alfalfa meal	Animal fat	Apple pomace
Brewer's dried yeast	Barley	Chicken fat	Barley
Chicken meal	Brewer's rice	Corn oil	Beet pulp
Chicken liver	Brown rice	Fish oil	Cellulose
Chicken	Carrots	Flax seed (full fat)	Citrus pulp
Chicken byproducts	Dried kelp	Poultry fat	Oat bran
Corn gluten meal	Dried whey	Safflower oil	Peanut hulls
Dried egg product	Flax seed	Soybean oil	Pearled barley
Duck	Grain sorghum	Sunflower oil	Peas
Fish	Ground corn	Vegetable oil	Rice bran
Fish meal	Ground rice		Soybean hulls
Flax seed meal	Ground wheat		Soybean mill run
Lamb	Molasses		Tomato pomace
Lamb meal	Oatmeal		
Meat byproducts	Pearled barley		
Meat meal	Peas		
Meat and bone meal	Potatoes		
Poultry byproduct meal	Rice flour		
Rabbit salmon	Wheat (ground)		
Soy flour or grits	Wheat flour		
Soybean meal			
Turkey			

In recent studies, home-prepared diets, when not formulated properly, can be considered risk factors for dog and cat health. Therefore, to minimize the risks, the formulation of home-prepared diets needs to be provided by an expert. A balanced diet can ensure better health and quality of life for dogs and cats (Pedrinelli et al., 2019). In addition to that, every patient has unique health concerns; some need a low-fat diet, and others need high-calorie formulas. In order to solve this problem, commercial foods are recommended as they have a healthy, standard, and suitable formula for cats and dogs.

Owners should be provided with counseling on the dangers of feeding pets a home-prepared or commercial diet. It is imperative to remember that the different mechanisms of quality control in chemical and bacterial food contamination in the manufacture of commercial foods, whether raw, dry extruded, or moist, often lead to recalls of moist and dry extruded diets. Consulting with an experienced veterinarian is strongly recommended to ensure a nutritionally balanced and safe homemade diet (Wills and Simpson, 1994; Wichert et al., 2002).

Discussion

Rickets, secondary hyperthyroidism, and renal failure have been determined as the most significant side effects of the exclusive use of meat in cat and dog diets. In this survey, we aimed to collect comprehensive information by acquiring data from books and articles. Also, by making suggestions on each of the problems of exclusive use of meat in the diet, we turned part of the study into a guide for animal lovers and owners, making it a complete manual for addressing the associated challenges. The findings are mostly new, and many people may not be aware of them. However, there is still a need for further research and study in this area to discover all the dimensions of the problems resulting from changes in the diet and how they affect the body's microbiota and metabolism.

Bobeck et al. (2020) studied how advances in understanding immune system function influence the way we feed livestock and companion animals. Nutrients like vitamins D and E, omega-3 fatty acids, and zinc, as well as feed additives like phytogenics and probiotics, have immunomodulating potential. Over-immunomodulation can reduce immune function and clearance of microbial infections. Further research in nutritional immunology will enhance our understanding of nutrition and diet's impact on health (Bobeck, 2020).

According to De Godoy et al. (2013), the US pet population of 70 million dogs and 74 million cats has led to increased interest in pet nutrition, particularly dietary fibers. Advances in canine and feline nutrition have improved health, quality of life, and longevity. Alternative carbohydrates from cereal grains, whole grains, and fruits have gained popularity in pet food. Studies show corn fiber is an effective fiber source for pets, while fruit fiber and pomace have good water-binding properties. Rice bran is an economical alternative to prebiotic supplementation, while barley is well-tolerated by adult dogs (De Godoy, Kerr, and Fahey Jr, 2013).

Butterwick et al. (2011) discussed the challenges and issues in developing nutritional guidelines for companion animals, including the National Research Council (NRC) guidelines, the AAFCO, and the Federation Europeans de l'Industrie des Aliments Pour Animaux Familiers (FEDIAF) (Butterwick et al., 2011). The 2006 NRC guidelines provide minimum and maximum amounts for each nutrient to facilitate the formulation of balanced diets for healthy animals. However, they contain a lack of clarity regarding nutrient requirements, leading to controversy. The 2006 NRC uses an improved method to estimate the energy density of food, recognizing that pet foods vary widely in nutrient density. Institutional challenges include the NRC's lack of direct financial support, restrictions on funding acceptance, and decisions about species priority for revision. Nutrient requirement reports face challenges in setting specific dietary recommendations for various groups due to a lack of available human data, biomarkers, and compliance with clinical trials. The new DRI framework considers nutrient requirements for chronic disease outcomes, making the establishment of specific DRI numbers more difficult. Practitioners are shifting away from absolute values for nutrient supply, acknowledging that nutrient requirements are variable and flexing with purpose, genotype, environment, economic climate, and nutrient source. Future committees must decide whether to continue formulating to ensure 'adequate' nutrition or follow human nutrition approaches.

Conclusion

The all-meat cat and dog diet should be further studied to help us better understand its long-term effects on health. Until enough studies are available, animals on all-meat diets should have annual health screening and physical examinations, including urinalysis and biochemical and hematologic analysis.

Article Information

Funding. The authors didn't receive funding.

Conflict of Interest. The authors declare no conflict of interest.

Authors' contributions. All authors contributed to writing, complementing, critically reviewing, and finalizing the manuscript. All authors have read and approved the final manuscript.

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