

Canine Plant- Based Nutrition

**A Resource
for Veterinary
Professionals**

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“Vets are rightfully skeptical about plant-based diets for dogs because historically people were creating unbalanced home-cooked diets, but that’s not the case anymore. Now there are commercially produced complete and balanced plant-based dog foods made with digestible and high quality ingredients that are free from the most common dog food allergens, and they deserve consideration.”

– Tiffany Ruiz Dasilva, VMD, cVMA

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Preface

Like most vets, I was once just a pet parent—doing my best to care for my dogs, and making sure I did all I could for them to be with me as long as possible. While still in college at Brown University, I remember feeling extremely overwhelmed when it came to what food to feed my two Yorkies, Prince and Nahla. I wanted to make sure they were getting the best food out there, but like most pet parents, I had no idea what that was.

Starting veterinary school at the University of Pennsylvania, I was confident that soon I would know the best food options to feed my dogs and to recommend for my future patients. Early on, like most of you, I discovered the perils of raw feeding, the dangers of grain-free, and why home cooking was not necessarily a good choice. I remember learning about the type of “meat” (if you could call it that) that went into pet food and being disgusted, but it seemed as though meat-based kibble diets were being touted as the only “good” option. I was disillusioned in learning that words such as “premium” and “holistic” had no legal definition and it turned out they were essentially just marketing tactics.

After graduation, I felt a sense of disappointment because I still wasn’t convinced the food I was feeding my dogs was the best option. As we all know, while nutrition basics are usually covered in vet school, the more practical approach to evaluating a pet food is not generally a part of the curriculum. It is instead provided via lunch talks sponsored by large pet food companies (and this continues far beyond vet school as most continuing education content on nutrition is sponsored by these same companies). Yes, I was feeding a nutritionally complete and balanced dog food from one of those large companies, and my dogs had no issues (yet)—but the ingredients list contained “chicken byproduct meal,” none of the remaining ingredients seemed particularly great, and although the company spoke about the importance of feeding trials, this particular food did not have one.

Following vet school, I began working in general practice where I was asked countless times by my clients what food they should be feeding. As long as the pet had no health issues or known food allergies, I always gave my standard answer. I had become so comfortable with those big name brands, that I felt at a loss for how to evaluate other diets. I was very busy, and there was never enough time for my own lunch, let alone to learn more about pet food. It wasn’t long until I realized that this answer did not satisfy me, so I

would need to find a better solution for my clients. But life got busier, I became a mom, and soon we were faced with a global pandemic. In response to the lack of access to veterinary care during the pandemic, I created an affordable, multilingual telehealth platform. I wanted to make veterinarians more accessible and provide a reliable source of information to support pet parents. Once in-person care returned, I received my veterinary medical acupuncture certification in an effort to explore how alternative pain management can improve the human-animal bond.

As it happens, the bond I had with my own dog would be the one to bring me back to nutrition. My Nahla was diagnosed with tracheobronchomalacia and inflammatory bowel disease shortly after the birth of my son. Although I was a vet, I was crippled by fear, sadness, and thoughts of how we would manage her disease when I left the veterinary hospital that day. For inflammatory bowel disease, nutrition is a key component of disease management along with medications. We did all we could and were able to keep her with us for another year and a half.

What we feed our dogs directly impacts their health. Food plays a significant role in defining the composition of the gastrointestinal microbiome as well as the gut-associated lymphoid tissue (GALT) cell composition in the digestive tract- both of which greatly influence overall health. In fact, diet is a principal risk factor of chronic inflammation in both dogs and humans. Dysbiosis- an imbalance between the types of organisms present in an animal's natural microflora- creates inflammation of the GALT, which allows for antigens to enter the bloodstream and results in chronic cellular inflammation. Chronic inflammation leads to the production of free radicals which can damage and destroy tissues and can lead to inflammatory diseases such as cancer, inflammatory bowel disease, and allergies. Therefore, pet parents play a large role in disease prevention and health maintenance through the food they choose to feed their dogs (Arrazuria et al., 2017; Dodds, 2016; Li et al., 2016; Dodds & Callewaert, 2016).

A day will never pass that I do not think of Nahla, and wish that I knew then what I know now. Because of her, I continued to realize the impact of diet on health and chronic disease. This is what led me to pursue my current position as the veterinarian at Wild Earth, a plant-based dog food company.

Before beginning my current role, I was a bit skeptical (well very skeptical, if I am being honest) about plant-based diets for dogs, as many veterinarians are. This is largely because in the past, owners were formulating their own homemade plant-based diets, which were often nutritionally deficient. Times

have changed though, and those seeking plant-based diets are now more likely to feed properly formulated commercial diets. I have worked tirelessly to gain expertise in canine nutrition through certifications and coursework, have spoken to leading experts in the field, and have come to see the many benefits of a plant-based diet for dogs, such as longevity and food allergy symptom relief.

Since I know (all too well) that there is not much time between patients to do research on alternative diets I have also worked to compile a repository of evidence-based research that supports plant-based feeding in dogs. As veterinarians, a key aspect of practicing evidence-based medicine is to think critically. Perhaps, in doing so, we may be able to adjust our mentality based on the overwhelming weight of evidence on the side of nutritionally sound plant-based diets.

It is my mission to educate both pet parents and veterinarians alike on the importance of nutrition, and how a nutritionally complete and balanced plant-based diet can meet the nutritional needs of dogs in a sustainable and cruelty-free way. I truly believe that lifelong learning and questioning is key, and I hope to be a reliable source of information to help dogs live longer, healthier, and happier lives.

Dispelling the *Myths*

Nutrition is of the utmost importance for both health maintenance and disease prevention and management. For this reason, one of the more important recommendations we will make is what type of food our clients should feed. After all, our patients rely on us to recommend a diet that is complete and balanced in order to optimize their long-term health and prevent disease.

Nutrition is the *fifth vital assessment*, and a nutritional assessment should be performed at *every appointment*.

Walking through the aisles at a pet store or shopping online for dog food can seem overwhelming with choices ranging from conventional meat-based kibble, to raw meat, to grain-free, to plant-based. Each comes with benefits and drawbacks, but all will claim to be the best. And to complicate matters even further, marketing also plays a role, so we will see words such as “holistic” and “premium” which sadly do not have a true legal definition when it pertains to pet food. If we feel confused, imagine how our clients feel. The sad reality is, of the many factors that play a role in what food a person decides to feed their dog, most of them do not take proper nutrition into account. And to complicate matters even more, there is an abundance of misinformation on the internet when it comes to nutrition. Thankfully, the truth is that if the food your client is feeding is nutritionally complete and balanced, chances are their dog will do just fine. But as we all know, each dog is an individual, and different foods may be better for different dogs.

The terms natural, organic and human-grade are defined by the AAFCO and USDA. Terms such as ancestral/paleo/keto, premium, ultra, and holistic are industry-created terms and are not defined by the AAFCO and USDA.

Traditionally, the most common diet choice has been meat-based kibble, and many people still believe that this is the “best” option. We will dive into how meat-based kibble came to be later, but ultimately humans believe that dogs should eat meat because they evolved from wolves. What people have failed to realize is that just because dogs have evolved from wolves, doesn’t mean they are wolves. This is just one of the many myths surrounding plant-based diets for dogs. I will get into each of them in more detail throughout this book, but will introduce many of them here.

Myth #1: Dogs are carnivores

While dogs do belong to the Order Carnivora, they are not classified as carnivores. Fun fact: Pandas also belong to the Order Carnivora—and we certainly know that pandas only eat plants.

Dogs differ from carnivores in many ways, but some of the most notable include:

- Dogs have lower protein and amino acid requirements
- Dogs can utilize the precursor provitamin A (found in plants) to form active vitamin A
- Dogs can more easily utilize vitamin D from plant sources
- Dogs can convert tryptophan to niacin
- Dogs can synthesize taurine

Dogs diverged from wolves over 15,000 years ago (that’s a long time ago!), and evolved alongside humans, eating their scraps which included grains, fruits, and vegetables. During domestication, dogs gained many copies of the gene responsible for starch digestion, just as humans did during the agricultural revolution. This makes dogs more accurately classified as omnivores rather than carnivores. What does this mean? Dogs can obtain nutrients from both plant and animal matter, and therefore they can thrive on a plant-based or meat-based diet.

Myth #2: Dogs need protein from meat

Dogs don’t need to eat meat, but they do need high quality protein. And you know what’s loaded with protein? Plants and fungi. The truth is, that the digestive system of a dog doesn’t care where the protein comes from — it matters that the protein is high quality, meaning it is complete, highly digestible, and bioavailable. We need to see beyond the misinformation that puts meat on a pedestal as the only appropriate source of protein. Protein-rich plant-based ingredients, such as soy, and yeast have been shown to be appropriate protein sources for dogs, and reportedly have digestibility similar to animal-derived ingredients (Dodd et al., 2018; Reilly et al., 2021; Clapper et al. 2001).

Myth #3: Plant-based diets are higher in carbohydrates and lower in protein than meat-based kibble diets

Plant-based isn't synonymous with carbohydrates as we may think, as protein not only comes from meat, but also comes from plants and fungi. In fact, most commercial dry dog foods typically contain a high proportion of plant ingredients, as a high grain content is necessary for successful extrusion. It is only a small step from some of the popular meat-based dry dog foods to one that contains no meat at all.

The reality is that a commercially produced plant-based kibble can have less carbohydrates and more protein than a meat-based kibble diet. In order to illustrate this point, I compared three plant-based kibble dog foods (one of which is hydrolyzed) to five popular and/or veterinarian-recommended meat-based kibble dog foods. I made sure to include a prescription hydrolyzed protein diet commonly prescribed for food-allergic dogs. As you can see on the following page, Wild Earth Performance and Petaluma Roasted Peanut Butter and Sweet Potato adult dog foods contain more protein and less carbohydrates on a dry matter basis than many of the leading vet-recommended dog food brands.

	Protein (DM)	Fat (DM)	Carbo- hydrates (DM)	Fiber (DM)	First Ingredient	Nutritional Adequacy Statement
Hill's® Science Diet® Chicken & Barley (Adult)	23.9%	14.7%	53.9%	2.1%	Chicken	Formulated
Purina® Pro Plan® Complete Essentials (Adult)	29.5%	18.2%	40.9%	3.4%	Chicken	Feeding trial
Royal Canin® Medium (Adult)	25.5%	13.3%	53%	3.6%	Brewers rice	Formulated
Royal Canin® Hydrolyzed Protein (Adult)	21.6%	19.4%	52%	3.4%	Brewers rice	Formulated
Blue Buffalo Life Protection Formula (Adult)	26.6%	15.6%	44.4%	5.6%	De-boned chicken	Formulated
Wild Earth Performance Formula (Adult)	31.1%	12.2%	43.3%	5.6%	Dried yeast	Formulated
Purina® Pro Plan® HA Vegetarian (Adult)	20%	8.9%	58.9%	4.4%	Corn starch	Formulated
Petaluma Roasted Peanut Butter & Sweet Potato (Adult)	31%	18%	39.2%	5%	Organic chickpeas	Formulated

All values are in dry matter. If ash content was not included in guaranteed analysis then the estimation of 7% was used.

Myth #4: A plant-based diet cannot be as nutritionally sound or as palatable as a meat-based diet

Plant-based diets for dogs can be nutritionally complete and balanced, they just need to be carefully formulated. If formulated correctly, they can not only meet but exceed AAFCO nutritional guidelines. Currently, we evaluate meat-based diets based upon whether they meet these guidelines, and the same method should be used to evaluate plant-based diets.

A 2021 study examined the steps taken to ensure the nutritional soundness and quality of plant-based pet foods and found that plant-based diets were produced at equal or superior standards to meat-based diets, with acceptable or superior standards overall at all stages of formulation (Knight & Light, 2021). Not only can commercially available plant-based diets be of high quality and be healthy, but they can also be delicious and satisfying to dogs. In 2021, a group of researchers from the University of Winchester surveyed the owners of 2,308 dogs (and 1,135 cats), and found that those who were fed plant-based diets for at least one year were just as eager to eat and just as healthy as those fed meat-based diets (Knight & Satchell, 2021).

Veterinarians have rightfully been very skeptical of alternative diets, including plant-based diets for dogs, because many past studies found that historically these were nutritionally deficient. The reason for this was that most people were formulating their own plant-based diets at home, and these, of course, were not nutritionally complete and balanced. In the last several years, however, there has been an explosion in evidence-based research that supports plant-based feeding of dogs, and now we have many commercial companies manufacturing these foods on an industrial level, and most of them are taking good steps to ensure that products meet a high standard and are nutritionally complete and balanced.

Myth #5: A dog's health will decline on a plant-based diet

More studies are being published that show plant-based food can be healthier for some dogs than conventional diets, and promote longevity. The most recent, comprehensive, and first long-term study was published in 2023. Fifteen clinically healthy client-owned dogs were fed a complete and balanced plant-based diet for a year, and the authors concluded that health was maintained (Linde et al., 2023).

Prior to this groundbreaking study, the authors of a short-term study published in 2021 came to a similar conclusion. Researchers evaluated the short-term amino acid, clinicopathologic, and echocardiographic findings in thirty healthy dogs fed a commercial plant-based diet for 12 weeks, and concluded

that the health of the dogs was maintained and did not deteriorate (Cavanagh et al., 2021). Another study, where sprint-racing sled dogs were fed a nutritionally complete and balanced vegan diet, demonstrated that a carefully balanced meat-free diet can maintain normal hematological values in exercising dogs (Brown et al, 2009). These studies, and many more, will be detailed later in *The Research Supporting Plant-Based Diets for Dogs*.

Still, one may ask, why choose plant-based over meat-based?

In this book, we will explore all these reasons in depth. First, there will always be clients interested in feeding plant-based. The sad reality is that if we do not agree with what a client wants to feed (and cannot provide evidence as to why it is not a good choice), they will either find someone else who does or just not tell us what they are feeding—and that does not benefit our patient. Knowing more about plant-based diets in general, and which commercial diets may be safe to recommend, will only serve to help our patients in the long run.

Second, the meat used in pet food is traditionally low-quality meat that is unfit for human consumption. That means “meat” by the broadest definition can come from dead, dying, diseased, and downed animals. I will explore the issues with meat, and why it should at the very least be questioned, later in *Dog Food Evolution and Safety*. Well, what about meat-based fresh and/or “human-grade” pet food? While it is likely to be a healthier food choice than meat-based kibble with higher digestibility, it can be prone to bacterial contamination, and it means that more animals are being slaughtered for our pets to eat.

The Association of American Feed Control Officials (AAFCO) is in the process of developing an official definition for human-grade foods, and this is expected to be published some time in 2023 after undergoing AAFCO’s formal approval process. If a pet food company claims that they are selling “human-grade” dog food at this time, the food does not have to meet any legal requirements.

Third and fourth are animal welfare concerns and the impact that raising and slaughtering animals has on our planet. According to a University of California Los Angeles (UCLA) study published in 2017, meat used for pet food accounts for 25–30% of meat consumed in the United States (Okin, 2017). This roughly creates about 64 million metric tons of greenhouse gas emissions per year, which is equivalent to the annual exhaust produced by 14 million cars. These numbers will only increase as the number of pets increases and more “human-grade” pet food (with actual regulation) hits the market.

If dogs and cats in the United States were their own nation, they would rank 5th in meat consumption (Okin, 2017).

Fifth, the most frequently reported food allergens involved in cutaneous adverse food reactions (CAFR) in dogs were beef (34%), dairy products (17%), and chicken (15%) (Mueller et al., 2016). Plant-based diets are inherently devoid of these ingredients, and therefore often offer symptom relief to those dogs with food allergies. It is interesting now to think that as veterinarians we are quick to recommend a diet where feather hydrolysate is the main protein source for a food-allergic dog, but hesitate to offer a nutritionally complete and balanced diet devoid of the most common food allergens and packed with whole food ingredients for that same dog.

Lastly, and arguably the most important reason of all—overall health. Plant-based food has been shown to lead to positive health outcomes in humans as well as dogs. For humans, multiple studies have linked plant-based diets to a lower body mass index (BMI), improved insulin resistance, reduced risk of cardiovascular disease, improved cardiac function, and decreased incidence of hypertension (Clem & Barthel, 2021). Furthermore, studies also suggest that plant-based diets may decrease modifiable risk factors for certain cancers as processed meats have been shown to increase the risk of developing cancer (Farvid et al., 2021). For dogs, research continues to emerge. The most recent studies, which are explored later in *The Research Supporting Plant-Based Diets for Dogs*, suggest that dogs fed a complete and balanced plant-based diet may be healthier and may live longer than those fed commercial meat-based kibble diets.

Plant-based dog food introduces an option for veterinarians and pet parents alike that can potentially improve overall health and longevity, help with symptoms caused by food allergies, support environmental sustainability and improve animal welfare on a large scale. This is not to say that all plant-based diets are created equal, and careful evaluation of the diet must be completed. In this book, I will discuss the science that supports plant-based diets for dogs, and situations where it may even be preferable to a conventional meat-based diet. I will also address each of the nutrients that dogs need, and how those are met by a carefully formulated, nutritionally complete and balanced plant-based diet. When it comes to general nutrition concepts, I will only touch upon the basics as a refresher. This is not meant to be an in-depth nutrition text, but rather a resource that allows for consideration of plant-based diets for dogs and provides direction on how to evaluate those diets critically.

Dogs Need *Nutrients*, Not *Ingredients*

“Dogs have dietary requirements for energy and essential nutrients, but they do not have a recognized requirement for animal-derived ingredients per se” (Dodd et al., 2018).

Dogs eat to acquire nutrients. Nutrients are compounds in food that the body uses for normal growth, maintenance, and repair, and they are either essential or non-essential. Essential nutrients are those that the body does not produce in sufficient quantities to meet the body’s demands, and therefore they must be obtained from the diet.

The six nutrient classifications are:

■ Water	■ Protein
■ Fat	● Carbohydrates
⌘ Vitamins	▼ Minerals

Only three of these nutrients are energy-producing, meaning they contribute to the calorie content and provide the body with energy. Those are protein, carbohydrates, and fat.

Ultimately all living organisms require energy for all bodily functions, and the amount of food an animal consumes is guided by the amount of energy they require. Feeding recommendations for each specific dog food will be based primarily on making sure a dog is receiving the appropriate amount of calories, or energy, and all remaining nutrients should be balanced relative to the energy density to make sure your patient is receiving the appropriate amount of all nutrients.

So yes, dogs eat to acquire nutrients (and energy). It is the ingredients that deliver these nutrients. Ingredient selection is of utmost importance when formulating a dog food, as ingredients are essentially nutrient vessels, and many work to provide a variety of nutrients.

This brings me to the term “complete and balanced”—what does it mean? To answer this question, let’s recall The Association of American Feed Control Officials (AAFCO). AAFCO is an organization made up of federal and state regulatory officials that has established nutritional requirements, guidelines

for standard ingredient definitions and product labels, and feeding trial protocols for pet foods. However, AAFCO does not directly test, regulate, approve or certify pet foods to make sure that they meet these standard requirements. Instead, pet foods are regulated at the state level. Most states follow AAFCO model regulations, however interpretation may differ between states.

AAFCO guidelines for pet food labels include:






1. Brand and product name
2. Species designation
3. Net quantity statement
4. Manufacturer or distributor information
5. Calorie content statement
6. Nutritional adequacy statement
7. Guaranteed analysis
8. Ingredient list
9. Feeding directions

As highlighted above, AAFCO guidelines for pet food labels include the nutritional adequacy statement, which explains whether the food contains essential nutrients, how that was determined, and for which life stage the food is appropriate for. Essentially, this statement lets the consumer (and veterinary professional) know if the food is “complete and balanced” for a particular life stage. For a dog food company to claim that their food is “complete and balanced” for a specific life stage, they must validate the claim either by nutrient content analysis or AAFCO compliant feeding trials. The nutrient content can be determined either from testing a sample of the finished diet, or by using the nutrient content of the individual ingredients in the food to calculate the diet composition. The former is preferred as ingredients are inherently variable in nutrient content as interactions with other nutrients and processing can alter bioavailability in the finished product. Although companies do not typically provide this information, you may contact the company to inquire about testing done on the finished product, quality control measures and the qualifications of the individual(s) formulating the diet.

To make sure that a dog is receiving the appropriate amount of nutrients from their food, it is important they be fed a diet for their specific life stage—adult maintenance or growth and reproduction. Puppies, pregnant and nursing dogs should be fed a food formulated for “growth and reproduction.” As you may already know, dog food formulated “for all life stages” is formulated to meet the nutrient requirements for growth and reproduction, which are different from non-reproducing adult dogs. In comparison with maintenance requirements for adult dogs, puppies require a more calorically dense food with higher concentrations of fat, protein, and essential minerals. Large and giant breed puppies have even more specific needs, especially with regard

to calcium. AAFCO guidelines now require pet foods that are categorized for growth to specify if they have met additional guidelines for puppies expected to be more than 70 pounds at their mature adult weight.

The age at which a puppy becomes an adult depends on breed size.

When Dogs Age to Adults	 Extra small	 Small	 Medium	 Large	 Extra large
Weight	<10 lbs	10-25 lbs	26-55 lbs	56-100 lbs	101 lbs+
Age	8 months	10 months	12 months	15 months	18-24 months

AAFCO has no official guidelines for senior pet nutrient levels, and therefore feeding senior diets is controversial as those products differ dramatically between companies. Seniors should be fed based on their individual needs, and senior products should be evaluated based on whether they meet those needs.

Senior dogs who have healthy kidney and liver function generally require higher protein levels in order to maintain optimal lean body mass.

Clients should be reminded to use the feeding guidelines only as a guide. Every dog is an individual, and therefore teaching your client how to assess their dog’s body condition is important.

Body Condition Score Guidelines:

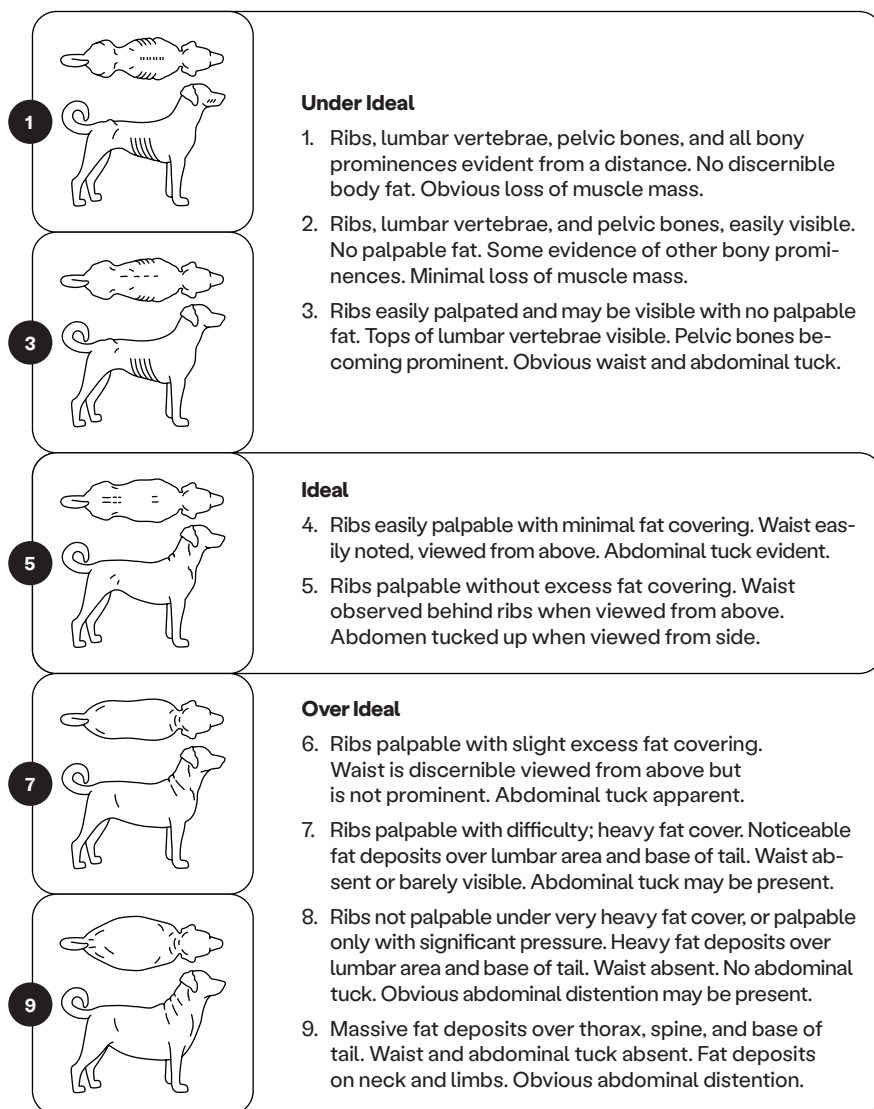


Figure A: Body Condition Score. World Small Animal Veterinary Association, 2013

Obesity is a growing problem for humans and dogs alike, and in North America, obesity is the most common preventable disease in dogs. The Association for Pet Obesity Prevention reports that more than 50% of dogs are overweight. Not only are overweight pets predisposed to a variety of chronic health issues such as joint disease, respiratory disease, and certain types of

cancer, but they are also found to live on average 2 to 2.5 years less than dogs of ideal body weight (Salt et al., 2019). For dogs, this equates to about 18% of their lifespan. While plant-based diets have not been clinically studied for weight loss in dogs, they have been studied in humans, and have been shown to be associated with a decreased BMI and decreased visceral fat (Clem, 2021).



**Treats should only make up
10% of a dog's daily calorie intake!**

All in all, the ingredients in dog food are used as vessels to deliver the nutrients that dogs need. After all, the body needs nutrients, not ingredients. Choosing high quality ingredients is of utmost importance because ingredients must be digestible—meaning they need to be able to be broken down for the body to acquire the nutrients contained in them—and the nutrients must be bioavailable, or able to be used by the body. Always make sure to critically evaluate the ingredient list.

Unfortunately, there is no way to easily determine the ‘quality’ of a product or identify the pet foods that have undergone more rigorous testing by simply looking at the bag. For this reason, the World Small Animal Veterinary Association (WSAVA) Global Nutrition Committee created guidelines on selecting pet food to help veterinarians better assess diets. Furthermore, the Pet Nutrition Alliance Dare to Ask website is a wonderful resource as they have contacted all 227 pet food manufacturers, asked a subset of WSAVA criteria questions, and posted their answers.

Later in this book, we will take a closer look at each of the essential nutrients for dogs. But first, let's dive into the domestication of dogs.

Calculating Dry Matter (DM)

You will see the term dry matter (DM) used throughout this book. As a reminder, dry matter removes the moisture content from the food in order to more accurately compare the nutrient profiles of foods that have different moisture contents.

$$\text{Nutrient dry matter \%} = \text{\% nutrient as fed basis} / (100\% - \text{moisture content \%})$$

A Dog Isn't a Wolf, Don't *Feed Them* Like One

Marketing has always played a role in what consumers believe to be the “best,” and this continues to be true today. Why do consumers (and interestingly enough, a lot of vets) think a dog is basically a wolf and needs to eat meat? Could it be from dog food commercials focused on wolves running and turning into dogs? Or marketing tactics making you believe the best dog food needs to have meat listed as the first ingredient? Or maybe it's from the new wave of raw diets which claim “ancestral feeding” (except that modern dogs' digestive systems are very different from their ancestors, and ironically it was us humans that helped change them). Wherever you've heard this before, I hope to shed some light on dog domestication and the unique nutritional needs of modern dogs.

Yes, dogs evolved from wolves, but the key word is evolved. A modern dog is not a wolf and should not be fed like one. Dogs descended from a population of wolves that are thought to have gone extinct towards the end of the Ice Age. The divergence of dogs took place as early as 40,000 years ago, with evidence of the first actual domesticated dogs found in human campsites occurring around 15,000 years ago. Since that time, there has been one other domestication event occurring in Asia, and that was about 12,000 years ago. Keep in mind that these are ballpark timeframes and a lot is still unknown.

So how did dog domestication occur? Ancient gray wolves and ancient humans both had similar family group structures, where communication and cooperation were important. This is thought to be the foundation for why they were able to evolve together. They lived near each other for thousands of years and would cross paths as they hunted some of the same animals. Most wolves were actually afraid of people and those are the ones that evolved to become today's modern wolves. At that time humans lived in hunter-gatherer societies, and the wolves that were less fearful, ventured closer to humans, eating the food scraps and waste near their human settlements. Humans, in turn, benefited from the protection these select wolves provided.

With a regular food source, these friendlier wolves flourished and had many offspring. They passed on their behavioral characteristics, namely that friendliness, to their offspring. As they evolved, they became smaller and much less aggressive. Other traits that accompanied friendliness included: their teeth became smaller, their snouts shortened, and they developed curly tails and floppy ears.

As humans shifted from hunter-gatherers to ones dominated by agriculture, starch became a larger part of their diet, and in turn, they had to become better at digesting starch. In humans, amylase is produced in the saliva and by the pancreas, and in dogs it is solely produced by the pancreas. At the outset of the agricultural revolution, which took place sometime between 11,500 and 6,000 years ago in western Eurasia, the genes responsible for producing amylase in saliva for humans were copied many times over in response to this selective pressure.

A similar process occurred in the ancestors of dogs, although the time frame remains vague. Since they lived alongside humans, they too began consuming more starch, and duplication of a gene called AMY2B gene, which is responsible for pancreatic amylase production, occurred. Modern day dogs have developed many more copies of these genes making them functionally omnivorous and able to eat and properly digest more starchy foods.

Gray wolves only possess 2–8 copies of this gene, with 60% of wolves having only two copies. As we know they are primarily carnivorous and likely more similar to early domesticated dogs. Dogs on the other hand can have anywhere from 4–34 copies, suggesting that dogs have adapted to a starch-rich diet. Interestingly, most dog breeds who were domesticated in agricultural hubs and have had the longest time to adapt to agriculture, have the most copies of this gene. Oppositely those who were bred by indigenous peoples inhabiting arctic regions where conditions are poorly suited for agriculture have fewer copies of this gene.

Did you know?

During the Victorian era (1837-1901) they bred dogs with interesting traits until they had *hundreds of different breeds*.



Compared to true carnivores, dogs not only produce more of the enzymes needed for starch digestion, but they also have much lower protein and amino acid requirements and can more easily utilize vitamin A and D from plant sources, just as people do. All of these factors make them more accurately classified as omnivores rather than carnivores, meaning they can do well on meat or plant-based diets (Heinze, 2016).

To further illustrate this point, a group of researchers set out to compare the genome of dogs to the genome of wolves in order to further shed light on the genetic changes that accompanied the transformation of ancient wolves into domestic dogs. They found that 36 regions of the genome differ, and were likely found to represent targets for selection during dog domestication. These regions contained genes that fell into two main categories—those genes important in brain function, and likely responsible for behavior traits, and those responsible for starch digestion and fat metabolism (Axelsson et al., 2013). As we well know, the temperament of a dog is not similar to that of a wolf, and this study illustrates the genetic basis for why that is. The ability of modern dogs to thrive on a diet rich in starch, relative to the carnivorous diet of wolves, constituted a crucial step in the early domestication of dogs.

Walker and colleagues set out to demonstrate just how well dogs were able to digest starch by cannulating the terminal ileum of 9 dogs and feeding a food containing 67% extruded corn, rice, oats or barley (Walker et al., 1994). They found that starch digestion was complete, with all grains being nearly 100% digested in the small intestine.

The differences between dogs and wolves do not stop at the AMY2B gene copy number. Before I go into these I just want to make a quick comment that, similar to most wild animals, the diet of a wolf is meant to maintain their health through their reproductive years. For our patients and pets, however, we are not feeding to meet basic needs—we are feeding for health and wellness. It is our goal for our own dogs and our patients to maintain health past their reproductive years and live longer than wild wolves.

Aside from how well they can digest starch, dogs differ from wolves in many other ways:

	 Dogs	 Wolves
Approaches human	✓	⊘
Can respond to human gestures (ex: pointing)	✓	⊘
Body size	Smaller	Larger
Mouth	Smaller jaws and weaker molars	Larger jaws and stronger molars
Legs	Shorter	Longer
Ears	Floppy	Pointed
Eye color	Range from brown to blue	Yellow
Heat cycle	2x/year	1x/year
Birth	Anytime of year	Spring
Communication	Bark	Howl

Humans have coevolved with dogs, and a 2015 study demonstrated that when a human and dog interact, both experience an increase in oxytocin levels (Nagasawa et al, 2015). Further, dogs look to humans for help during tasks, whereas socialized wolves do not (Miklosi et al., 2003).

Now that we know that dogs differ from wolves and can digest starch with ease, let’s explore whether their nutritional needs can be met, and whether they can thrive on a plant-based diet.

Dog Food Evolution and *Safety*

As we just learned, dogs have been domesticated for thousands of years, and as early as 2000 BCE humans have been giving consideration to what they feed their dogs. Prior to the Industrial Revolution, dogs were rarely fed meat. Examples of what dogs were fed are milk-soaked barley, bones, cabbage, potatoes, and crusts of bread.

In the 1800's, with the Industrial Revolution giving rise to a more affluent middle class, humans began seeing pets as companion animals instead of simply working animals. By 1850, it became common practice to buy horse meat from the working horses that would die in the streets to feed to pet cats and dogs alike in certain cities. The science of veterinary nutrition began to emerge in the late 1800s and has continued to evolve. The first commercial dog food was created in 1860 by James Spratt which was made from "a mix of wheat meals, vegetables, beetroot, and beef blood", and was inspired by the biscuits eaten by sailors that Spratt saw being fed to dogs. In 1922, canned dog food was introduced, with the main ingredient being horse meat, and it became so popular that roughly 50,000 horses per year were slaughtered to meet the demand.

During World War II, tin and meat were rationed, and big names such as General Mills and the Ralston Purina Company entered the scene as the former acquired Spratt's business and the latter began experimenting with the methods used to create their Chex breakfast cereal. In 1956 the first dry kibble was produced via extrusion, Purina Dog Chow, using the same methods used to produce cereal. In 1964, a group of pet food industry lobbyists (The Pet Food Institute) launched a series of very successful ad campaigns convincing consumers to feed a commercially prepared meat-based dog food. The dog food industry boomed with a focus on money, but thankfully history was able to be corrected with the introduction of governing bodies and legislation. In the mid-1980's the first nutritional requirements for dogs and cats were published in the US to ensure manufacturers were taking responsibility for their product, and since then, research has continued to ensure pet food is safe and

has a minimum level of nutrition. Using scientific research, AAFCO continues to adjust pet food standards in order to improve the pet food industry, paving the way for new ingredients to be used to offer complete and balanced meals.

What have we learned from this timeline? The two main takeaways are:

1. Humans have always shown an interest in what to feed their dogs and opinions have always varied on what is best.
2. Competitive capitalism has played a huge role in how pet food has evolved and what owners believe to be best.

For better or worse, humans have essentially controlled the evolution of canine diets and this influence is the reason dogs eat what they eat. Over the years, even the microbiomes of dogs have evolved to be more similar to that of humans. In a 2019 study, researchers compared the microbiomes of dogs to that of humans and wild wolves. Using microbial gene sequencing technology, they analyzed the 169 fecal samples from dogs (spanning 51 breeds), 79 from healthy adult humans, and 6 from wild grey wolves. The results demonstrated that dogs have not only gained five taxa present in the human core microbiota, but they have also lost six bacterial genera typical of the wolf core microbiota. The authors concluded that while dogs still maintained some commonalities with wolves, the gut microbiota has been “extensively shaped by artificial selection, altered diet and close contact with humans” (Alessandri et al., 2019). Even further, another study concluded that the canine gut microbiome overlaps with the human microbiome by 63%, and this overlap must be attributed to similar physiology and lifestyle rather than solely to transmission (Coelho et al., 2018).

Traditionally, the majority of pet owners feed a commercial meat-based kibble because lobbyists have worked hard to create ad campaigns touting these foods as “the best”. However, as stewards of our patient’s health, it is important to think critically about what is considered “best.”

Americans are spending more money than ever before on their beloved pets, and a large portion of this goes towards what’s in their food bowl, but what are they paying for? Traditional meat-based kibble typically contains the parts of animals that may be unfit for human consumption, ranging from organs to those animals that are down, dead, dying, and diseased (“4D”). While the use of “by-products,” the non-rendered parts of the animal other than the meat, is environmentally responsible, it can add a question mark to what is actually in the food. Essentially it is a method often used to keep protein levels high (but not always high quality), and food production costs low. The more problematic meat ingredients, however, are those designated as “meal,” which are the result of rendering. Rendering is defined as “an industrial process of extraction by melting that converts waste animal tissue into usable materials.” In other words, it is

a process by which animal parts that are generally unfit for human consumption (including expired meats, the 4D meats, and even animals who have drowned after a flood) are chopped up and boiled into a stew which is then dehydrated. The fat and protein portions are then removed and used as animal fat or ground up into “meal,” respectively. To further compound the problem, if the general term “meat meal” is used, the animal the parts came from is not disclosed. Even if a specific animal is named on the label such as “chicken,” for example, meat is often mislabeled, meaning what is on the bag isn’t necessarily what is inside. In 2015, a Chapman University research team looked at 52 commercial pet foods, and found that 40% of those tested contained mislabeled meat products (Okuma & Hellberg, 2015).

To add to concerns surrounding meat-based dog food, meat is much more likely to become contaminated with bacteria such as Salmonella. There have been over 180 dog food recalls since 2009, and major ones from bacterial contaminants from meat sources. In fact, 49% of all pet food recalls in the past ten years have been from pathogenic bacteria. The second leading cause of pet food recalls is pentobarbital, a euthanasia drug. In 2018, the director of FDA Center for Veterinary Medicine addressed this, stating “we have reason to believe rendered products can be a source for pentobarbital” (FDA.gov, 2018).

Ten Years of Pet Food Recalls

Total: 327,140,539 lbs
Total kibble: 66%
Total can: 32%
Total raw: 0.6%
Total other: 0.1%

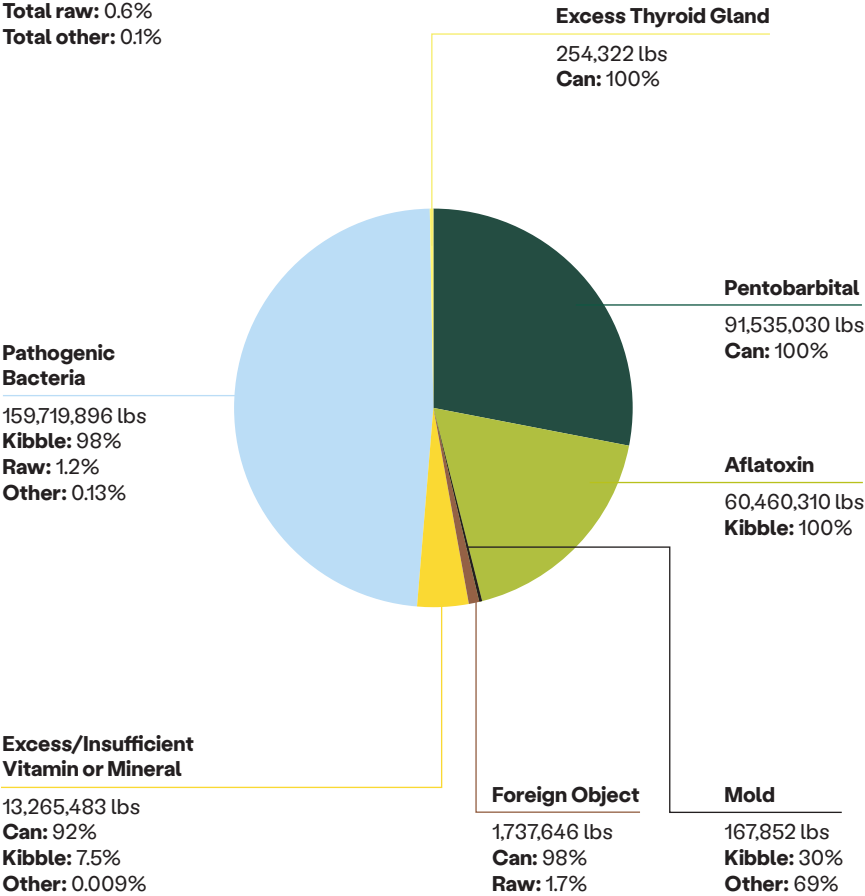


Figure B: Ten Years of Pet Food Recalls. Truthaboutpetfood.com, 2021

Further, meat-based pet food has not only been found to contain pen-tobarbital, but it has also been found to contain hormones, antibiotics, and toxic amounts of heavy metals. The Clean Label Project, a national nonprofit focused on health and transparency in labeling, tested the top pet foods and found lead in some pet foods at 16 times the concentration of lead in Flint, Michigan’s tainted drinking water. They also found arsenic in concentra-tions of 555 times higher than the maximum contaminant level for human drinking water set by the Environmental Protection Agency.

Protein—Yes, *Plants* Have Protein

Plant-based protein can offer the same benefits as animal-based protein, without the allergens.

Proteins are made up of amino acids, which are classified as essential, non-essential, and conditionally essential. There are 20 amino acids which can come together in a wide variety of numbers and sequences to make different proteins with different functions. Dogs do NOT have a protein requirement. They have a requirement for amino acids and nitrogen.

Essential amino acids include:

Arginine	Lysine*	Tryptophan
Histidine	Methionine*	Valine
Isoleucine	Phenylalanine	
Leucine	Threonine	

* Methionine and lysine are typically "limiting amino acids," which means they are typically provided in the lowest amount in dog food, therefore providing the limitation on protein synthesis. Some dog food manufacturers will choose to include these in their guaranteed analysis to demonstrate to consumers and veterinarians that they are meeting the AAFCO recommendations.

Non-essential amino acids include:

Alanine	Glutamate	Hydroxyproline
Asparagine	Glycine	Proline
Aspartate	Hydroxylysine	Serine

Conditionally essential amino acids include:

Cysteine
Glutamine
Tyrosine

Essential amino acids are those that must be obtained from the diet, whereas non-essential amino acids are those that can be made by the body. Conditionally essential amino acids are those that must come from the diet during times of stress, such as disease.

Amino acids are the building blocks of protein, and protein plays many critical roles in the body. Proteins are the main structural component of organs and tissues such as muscle, function as hormones and enzymes, and provide a source of energy.

Protein sources vary in level of quality. Protein quality refers to the efficiency by which amino acids from food are converted into tissue. That efficiency depends on protein source, concentration of essential amino acids in the food, and their bioavailability. Protein sources that are highly digestible and provide all 10 essential amino acids in relatively appropriate amounts are considered high-quality, or ‘complete’, and this can be true for both plant and animal sources. Soybean meal, for example, is designated as a “good” quality protein in the Small Animal Veterinary Nutrition Textbook. Furthermore, studies have concluded that yeast and soy are considered appropriate alternatives to poultry meal as the main protein source in dry, extruded canine diets (Reilly et al., 2021; Clapper et al., 2001).

While it is true that many animal sources of protein are considered high quality, such as chicken and beef, this is not always the case for the meat sources used in pet food. Rendered byproduct meals commonly used in pet foods, for example, have much lower amino acid digestibility, and are therefore lower in protein quality, than raw animal meals (Cramer et al., 2007). These animal sourced ingredients, specifically chicken and beef, are also some of the most common food allergens for dogs.

Even if a protein is ‘complete,’ most dog food manufacturers make use of protein complementation when formulating complete and balanced diets.



What is protein complementation?

Protein complementation is the use of different protein sources with complementary amino acid profiles to create a complete amino acid profile. It is a common practice in both plant-based and meat-based dog foods. This is why you will often see plant sources of protein, such as yeast and soy, used in meat-based dog food, and why dog foods may contain more than one protein source. Generally, the higher quality the protein, the less complementation is needed.

Whether we like it or not, the reason that “meat” has become synonymous with “protein” is because of politics. The meat industry in the United States is a powerful political force, both in the legislative and regulatory arenas. Lobbying organizations such as the National Meat Association and the American Meat Institute work hard to prevent new meat-safety initiatives and improve-

ment of animal welfare (because oftentimes that means decreased productivity). These lobbying organizations have had a long-standing relationship with The Food Safety and Inspection Service (FSIS) which is the government agency in charge of regulating the meat industry.

Furthermore, we have been conditioned to look for meat as the first ingredient, and believe this to be the true marker as to whether a dog food is “bad” or “good”. This can be misleading, however. Raw chicken is a quality item, but contains up to 73% water. After cooking, most of that moisture is lost, reducing the meat content to just a fraction of its original weight. Therefore, even if chicken is listed as the first ingredient, once water loss is accounted for, it would drop down on the ingredients list. The fallacy that meat must be the first ingredient on an ingredient list has also led to the common practice of ingredient splitting.



What is ingredient splitting?

Ingredient splitting is a way to artificially boost a desirable item (like meat for example) to a higher spot on the ingredient list while lowering the ranking of a less desirable ingredient. The ingredients on an ingredient list are listed in order of its precooking weight. Let's consider an example where a manufacturer creates a dog food that contains rice as the main ingredient of the recipe, and some chicken. An ingredient list would have rice listed as the first ingredient. If the manufacturer breaks rice into smaller portions of similar ingredients, however, such as white rice and brown rice, then they can fall further down on the ingredient list and chicken can then be listed as the first ingredient.

We now know that dogs do not need to eat meat, and can receive high-quality protein from plants and fungi.

Whether from animal or non-animal sources, the AAFCO minimum protein requirement is 18% DM for adult maintenance and 22% DM for growth and reproduction. Protein needs are higher during growth, pregnancy, lactation, or when there is tissue damage, which, again, further demonstrates the importance of choosing a dog food that is appropriate for a dog's life stage. If more protein is eaten than is needed, it will be stored as fat. We are constantly bombarded with “the higher the protein, the better” but there is no nutritional reason that supports providing excessive amounts of dietary protein. After the nitrogen and amino acid requirements are met, additional protein provides no additional benefit and excess protein adds unnecessary cost to food (Hand et al., 2010). Excess protein is used for energy, and as an energy source, protein is no better than a digestible carbohydrate.

Carbohydrates— *Friend or Foe?*

Carbohydrates not only supply glucose, but they play several other roles in the body. While omnivores have an energy requirement, they do not have a carbohydrate requirement per se because they can also use protein and fat for energy. This is the basis for the argument many proponents of raw feeding and keto diets try to make. And this would be a valid argument if it weren't for several very important points.

First, carbohydrates, in particular simple carbohydrates and starches, are the easiest forms of energy for the body to break down. If there are not enough carbohydrates to produce the necessary glucose, amino acids will be shunted away from muscle growth, for example, to be used for glucose synthesis.

Second, and along the same vein, the alternative to not feeding carbohydrates is increasing the protein or fat content of a food to meet the body's energy requirement. Protein is not only expensive, but we are facing a climate crisis so adding more protein to a diet, when carbohydrates can play the same role, is irresponsible. As for fats, a group of researchers published a study in 2022 that compared the inflammatory response of dogs fed a high-starch vs. a high-fat diet and found that starch digestion conferred benefits that the high-fat diet did not such as anti-oxidative effects (Lyu et al., 2022).

Third, carbohydrates, specifically fiber, are important for proper functioning of the digestive tract. Fiber is a type of complex carbohydrate and serves as nutrition for the beneficial gut bacteria. The result, a healthy digestive system.

And fourth, fruits and vegetables, which are considered carbohydrate sources, are packed with nutrients such as vitamins and minerals.

Yes, carbohydrates have been villainized in our culture, but have you ever thought to ask yourself why?

To answer this question, we need to take a deep dive into the different types of carbohydrates that exist, and which ones are commonly used in pet food.

Carbohydrates are commonly classified as simple versus complex. Simple carbohydrates include glucose, sucrose, and lactose, for example. Complex carbohydrates include starch and fiber. Starch can be broken down by mammalian enzymes and is therefore the main carbohydrate source used in com-

mercial dog foods, as it can be easily digested and is necessary for successful extrusion of kibble.

When heated, starches undergo a process called gelatinization, which makes them easier to digest.

Fiber cannot be broken down by mammalian enzymes, and instead is broken down by microbial enzymes, providing a food source for the bacteria in the large intestine. Upon fermentation of the fiber, these bacteria produce short-chain fatty acids (SCFAs) that nourish intestinal cells, help maintain the normal intestinal electrolyte fluid balance and intestinal motility, ameliorate intestinal inflammation, and prevent the overgrowth of pathogenic bacteria.

Fiber aids in managing diseases such as obesity, diabetes, diarrhea, and constipation. It can be classified based on fermentability—basically its potential to be broken down by intestinal bacteria, produce SCFAs, and confer beneficial effects on the gastrointestinal tract. Fibers with low fermentability are not broken down as they pass through the intestines and therefore act as bulking agents. Highly fermentable fibers are rapidly metabolized by intestinal bacteria, resulting in overproduction of gas, which can cause diarrhea and cramping. Moderately fermentable fibers produce the beneficial effects associated with the production of SCFAs without the undesirable effects seen with rapidly fermentable fiber. Ideal fiber sources contain both a moderately fermentable portion and a nonfermentable portion to facilitate SCFA production and provide bulk, respectively (Sanderson, 2008).

Maintaining a healthy gut flora and gut lining is important as they act as barriers from invasion by gut pathogens. In fact, imbalances in the gut microflora have been linked to diseases such as allergies and inflammatory bowel disease. This should not be too surprising as 70%–80% of the immune system is located in the wall of the intestinal tract, making the gut-associated lymphoid tissue (GALT) the largest immune organ in the body. As I mentioned in the Preface, dysbiosis creates inflammation of the GALT, which allows for antigens to enter the bloodstream, resulting in chronic cellular inflammation, and ultimately, chronic inflammatory disease.

Getting back to the question I posed—why are carbohydrates villainized? Well, it's because of simple carbohydrates. Simple carbohydrates include processed sugars such as table sugar, and refined grains which are those that have had their fibrous and nutritious parts removed, such as white flour. Rest assured, these are not generally included in commercially prepared dog foods.

Unfortunately, when many people think plant-based, they think carbohydrates. But the reality is that a commercially produced plant-based kibble diet can have less carbohydrates and more protein than a meat-based kibble diet, as illustrated by the chart on page 10.

Calculating Carbohydrates

$\text{Carbohydrates \%} = 100\% - \text{crude protein \%} - \text{crude fat \%} - \text{crude fiber \%} - \text{ash \%} - \text{moisture \%}$

There is no official carbohydrate level recommendation provided by AAFCO. The carbohydrate level in most commercial dog kibble ranges from 30%–65% DM. As for fiber, AAFCO requires that maximum fiber content be listed in the guaranteed analysis.

As a final note, be aware that a common starch used in meat-based dog kibble is wheat, which is the fourth most common dog food allergen, following beef, dairy and chicken.

Fat—The *Importance* of Omegas

Why do dogs need fat in their diet? First and foremost, fat is the most concentrated form of energy, meaning it provides more energy than either carbohydrates or protein—2.5 times more to be exact. Aside from providing energy, fat provides essential fatty acids, allows for the absorption of fat-soluble vitamins A, E, D and K, and plays many vital roles in the body. It also gives food a better texture. Once digested, fats are broken down into fatty acids, which are classified as saturated or unsaturated. Saturated fats are those which contain no double bonds, and whose carbon atoms are therefore saturated with hydrogens. Unsaturated fats are those that have double bonds between carbon atoms. Monounsaturated fats have only one double bond, and polyunsaturated fats have more than one double bond. To further classify fatty acids, they are either considered essential or non-essential based on whether they must be obtained via the diet. Essential fatty acids are polyunsaturated and belong either to the omega-3 or omega-6 family, which differ with respect to the location of the first double bond as well as their effects on the body. Omega-3 polyunsaturated fatty acids (PUFAs) have anti-inflammatory effects, while omega-6 PUFAs are pro-inflammatory.

The omega-3 essential fatty acids are alpha-linoleic acid, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA). Alpha-linoleic acid can be converted into EPA, but dogs are unable to convert alpha-linoleic acid to DHA as efficiently. Therefore, DHA should be provided in the diet in sufficient amounts to support optimal health, which is especially important for puppies and seniors. Non-animal sources of DHA and EPA are phytoplankton and marine algae.

The omega-6 fatty acids include linoleic acid, gamma-linoleic acid, and arachidonic acid. Unlike cats, dogs are able to synthesize gamma-linoleic and arachidonic acid from linoleic acid in order to meet their needs, therefore only linoleic acid is considered essential.

In addition to their role in immune function, omega-3 PUFA's play a vital role in cell membrane structure and function, brain, heart, joint, skin, and coat health. Omega-6 fatty acids are involved in blood clotting, metabolism regulation, and are required for normal growth and development, reproduction, brain function, skin, and coat health.

As mentioned, omega -3 and -6 PUFAs work together to control inflammation. Omega-3 PUFAs produce hormones that decrease inflammation, while omega-6 PUFAs have a pro-inflammatory effect, which is an important part of the immune response. Balance between the two is imperative to maintaining a healthy immune system, resulting in maximum positive health effects. If the diet is too omega-6 heavy, chronic inflammation may result, potentially leading to health issues such as allergies, arthritis, inflammatory bowel disease, and cancer. Conversely, if the diet is too omega-3 heavy then the immune system cannot function appropriately. Although there is no conclusive data regarding the optimal omega-6:omega-3 ratio, and the AAFCO recommendation allows for levels up to 30:1, most veterinarians agree that a 4:1 ratio is ideal. Some dog food manufacturers will include the omega-3 and omega-6 levels in the guaranteed analysis for transparency.

Each distinctive fat source provides differing amounts of these essential fatty acids, and therefore must be expertly chosen to provide the correct quantities of omega-3 and omega-6 essential fatty acids. Both animal and plant sources of fats and oils are traditionally used in commercial meat-based kibble production, however, essential fatty acid requirements can be met, and even exceeded, using plant-based ingredients alone. Flaxseed, for example, is plentiful in omega-3's, whereas sunflower oil is plentiful in omega-6's. Furthermore, as mentioned, phytoplankton and marine algae can be used to provide DHA and EPA.

It is important to note that the AAFCO minimum fat requirement is 5% DM for adult maintenance and 8% DM for growth and reproduction.

Vitamins and Minerals

Minerals play diverse and important roles in the body, acting as structural components of tissues and organs, part of body fluids, and catalysts and cofactors in enzyme and hormone systems. They are classified as macro vs. micro based on whether they are required from the diet in larger percentage amounts or smaller parts per million (ppm), respectively. Minerals must be maintained in specific concentrations for optimal growth, health, and fertility.

Macrominerals include:

Calcium	Potassium
Phosphorus	Chloride
Sodium	Sulfur
Magnesium	

Microminerals include:

Iron	Selenium	Fluorine
Zinc	Manganese	Boron
Copper	Cobalt	Chromium
Iodine	Molybdenum	

Historically, meat-based diets have been thought to provide more available sources of certain minerals than plant-based diets because they contain organic forms of minerals (meaning the mineral is bound to a molecule containing carbon). Not only are organic minerals thought to be more available, but anti-nutritional factors found in plants, such as certain fibers, may reduce mineral availability. A group of researchers investigated the validity of these claims by feeding eight dogs two vegetable ingredient based diets versus two animal ingredient based diets, and measuring the digestibility of minerals. They found that the digestibility of minerals were actually similar or greater in dogs fed diets that are vegetable-based compared to those fed diets that are animal-based (C. L. Cargo-Froom et al., 2017).

Not only was the bioavailability of endogenous minerals in vegetable ingredient based diets found to be higher, demonstrating that plant-based diets can provide the necessary minerals that dogs need, but also the reality is that many of the minerals in both plant-based and meat-based dog food today come from supplemented minerals. This means that while many of the ingredients used to prepare commercially available dog foods contain minerals, supplemental minerals are usually added to the food as “premixes.” Premixes help ensure that the correct levels of the micronutrients are evenly distributed in the finished product. Organic forms of minerals (aka chelated minerals) are also commercially available as premixes. Chelated minerals, often used in high quality dog foods, are those that are already bound to amino acids, which may make it easier for the body to absorb and metabolize for critical functions essential to health. Chelated and non-chelated forms are often used together to ensure adequate mineral levels.

How do you know whether a dog food contains chelated minerals? Chelated minerals can be identified in the ingredients list on a pet food label as a “proteinate” or “chelate.”

Similar to minerals, vitamins must be maintained at optimal concentrations to avoid deficiency or toxicity, and are also added as premixes to ensure nutritional adequacy and safety.

Vitamins function to help regulate processes in the body. They have incredibly diverse physiologic functions, and are classified as fat-soluble or water-soluble. Fat-soluble vitamins—vitamins A, D, E, and K—are stored in fat in the body, and therefore daily intake is not as vital. Water-soluble vitamins, such as B vitamins and vitamin C, however, must be consumed daily.

**Water soluble
vitamins
include:**

Thiamin (B1)	Pyridoxine (B6)	Cobalamin (B12)
Riboflavin (B2)	Pantothenic acid	Biotin
Niacin	Folic acid	Vitamin C

**Fat soluble
vitamins include:**

Vitamin A	Vitamin E
Vitamin D	Vitamin K

Several of these vitamins have historically been isolated from animal sources, however, plant sources have been identified for many of those. For the remaining, synthetic versions can be used when formulating plant-based diets. The body is able to use naturally formed and synthetic vitamins in the same way, although they may have different availabilities (Hand et al., 2010). To account for these differences, as well as the effects food processing has on vitamin stability and availability, fortification of the food to meet a dog's vitamin requirement for their life stage, overcome processing and storage losses and avoid toxicity with supplemental vitamins is necessary. This is to say that, similar to minerals, nearly all commercial pet foods contain added vitamins as formulating a pet food to meet vitamin requirements entirely from ingredient sources is extremely challenging.

As a reminder, it is important to choose a complete and balanced food for a dog's specific life stage. Each life stage not only has unique energy and macronutrient needs, but they have different requirements for vitamins and minerals as well, with growing and reproducing animals requiring higher levels. Furthermore, given that both vitamins and minerals are supplemented in the majority of commercially available diets, vitamin and mineral supplements are not necessary unless managing a certain disease that affects vitamin metabolism.

Common Concerns for *Plant-Based* Diets

When it comes to plant-based diets, essential amino acids and nutrients that are traditionally derived from animal sources are of greatest concern. These include the sulfur-containing AAs methionine, cysteine, and taurine; the omega-3 polyunsaturated fatty acid DHA; and vitamins A, B12, and D.

Let's begin with taurine and its precursors—sulfur-containing essential amino acids methionine and cysteine. Taurine, although not an essential amino acid, may be conditionally essential particularly for breeds susceptible to taurine-deficient conditions. In dogs, taurine is conjugated with bile acids, leading to high losses through feces. Diets high in fermentable fiber, such as plant-based diets, may exacerbate this loss as they may result in increased bile acid excretion and microbial degradation of these taurine-conjugated bile acids. When evaluating a plant-based diet, it is crucial to ensure that both taurine precursors (sulfur containing amino acids) and taurine are added. “Non-animal sources of these nutrients are readily available, their bio-availabilities have been determined, and they are already used by animal feed industries.” (Dodd et al., 2018).

Now moving on to DHA. DHA, while not considered essential for adult non-reproductive dogs, is essential for gestation, lactation and growth. Contrary to popular belief, DHA is not only concentrated in fish oil, but is also concentrated in marine plant products, such as algae. Therefore, plant-based foods can be formulated to meet DHA requirements (Dodd et al., 2018).

As for vitamins, non-animal sources of most vitamins exist, however vitamins A, B12 and D are primarily sourced from animals. While vitamin A (retinol) is found exclusively in animal tissues, dogs, unlike cats, can utilize the precursor provitamin A carotenoids to form active vitamin A. Provitamin A carotenoids are found in many plants that can be used to formulate canine diets. Examples include vegetables rich in beta-carotene, such as pumpkin and sweet potatoes. Additionally, synthetic vitamin A analogs can also be utilized when formulating plant-based canine diets (Dodd et al., 2018).

Next, let's discuss vitamin B12, also known as cobalamin. Although cobalamin is produced by microbes in a dog's gastrointestinal tract, it is produced caudal to the site of absorption—therefore dogs need cobalamin from their diet. Historically, cobalamin has been sourced from animal tissues for use in

dog food, however now a bioavailable synthetic version of cobalamin (produced from microbial fermentation) exists—and it is used in both plant-based and meat-based pet foods. The addition of synthetic cobalamin to plant-based diets therefore fulfills the dietary requirement for dogs (Dodd et al., 2018).

Lastly, although most animals can synthesize vitamin D in their skin with adequate UV or sunlight exposure, dogs have a strict dietary requirement for vitamin D because they have high enzymatic catabolism of vitamin D precursors. Dietary sources of vitamin D include vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol). Vitamin D3 is more active in most animals, including humans, however dogs may be able to use both efficiently. Vitamin D2 is plentiful in fungi and yeast. While vitamin D3 has traditionally been derived from sheep lanolin or fish oils, it has also been isolated from plants, such as microalgae, and it is bioavailable. Additionally, commercial preparations of plant-sourced vitamin D3 exist. Therefore, it is entirely possible for a plant-based diet to meet the vitamin D requirement of dogs. If there is concern regarding the vitamin D status of a dog fed a plant-based diet, veterinarians can monitor serum calcidiol concentrations (Dodd et al., 2018).

All in all, when formulating plant-based diets, special care must be taken to ensure that all nutrient requirements are met, especially requirements for methionine, taurine, DHA, vitamins A, B12 and D which have historically been sourced from animals. As explored, plant-based or synthetic versions of these exist, and therefore plant-based diets can be formulated to be nutritionally complete and balanced.

Comparing Plant-Based Diets to *Other Diets*

Whether someone is feeding their dog raw meat, traditional meat-based kibble, or plant-based they likely feel strongly about the benefits of their decision. Feeding our pets is a way that we are able to strengthen the human-animal bond, and in many cases humans think more about what to feed their pets than what they eat themselves. While it may be difficult for some pet owners to understand diseases and treatments, providing their pets with food is an easy way for them to feel as though they are directly influencing their pet's health.

Today, it is easy to access information. However, what is often overlooked by clients is that it is just as easy to access misinformation. As I have explained, the pet food industry and the pet industry in general often relies on pet parents' lack of knowledge, therefore it is important for veterinarians to be the preferred, expert source of nutritional information for pets.

If you feel unable to work with your client to find a food or feeding style that satisfies both of you, refer them to a board certified veterinary nutritionist, and follow up to make sure your patient is being fed a nutritionally complete and balanced food.

In this chapter, I will compare a plant-based diet to other popular diets, including traditional meat-based kibble diets and raw meat-based diets (RMBD). Please keep in mind I am discussing only commercially-available diets. I will not be discussing homemade diets as these are often nutritionally incomplete and unbalanced, and may pose additional health risks.

As mentioned earlier, the reason meat is often a large part of a dog's diet primarily rests on the misconception that dogs are carnivores like wolves, and

therefore need animal-based ingredients to thrive. I hope that by now, you realize this is untrue.

Let's begin with raw meat-based diets (RMBDs). Types of commercially available RMBDs include (Stogdale, 2019):

1. Commercial raw frozen, freeze-dried, or dehydrated meat diets that are not complete and balanced. These require the addition of a combination of bones, a vitamin and mineral mix, vegetables, and fruit.
2. Commercial raw frozen complete and balanced diets with a variety of protein sources. Some are limited to one protein source, especially those using exotic meats. Freezing kills a variable percentage of bacteria.
3. Commercial freeze-dried complete and balanced diets that have been frozen under vacuum to remove nearly all moisture. Freeze-drying leaves the food nearly unchanged compared with raw frozen diets, and kills a percentage of bacteria.
4. Commercial dehydrated complete and balanced diets that have been heated slowly to remove nearly all the moisture. Whether the low heat has a significant effect on the nutritional quality of the food is unknown. The drying results in a reduction of microbial numbers but *Salmonella* and other pathogenic bacteria can survive.
5. Commercial high pressure pasteurized (HPP) complete and balanced diets that have been subjected to high pressure without heating. This process kills most bacteria including *Salmonella* and *Listeria* without altering nutritional quality.

When compared to meat-based kibble diets, a 2021 study based on data from a questionnaire found that dogs fed a RMBD in their postnatal period (1–6 months of age) had a lower risk of developing inflammatory bowel disease later in life, whereas those fed kibble had a higher risk (Hemida et al., 2021). The authors attributed this to a change in the microbiome of RMBD-fed dogs, however these same possible alterations in the microbiome led to adverse effects in another study. In the study, 33 dogs were fed either a “sensitive skin” meat-based kibble diet or a commercial raw food diet (Anturaniemi et al., 2020). While those fed a RMBD had several positive changes on blood work such as a lower serum cholesterol, alkaline phosphatase and glucose, they also experienced a significant decrease in folate, B12 and iron. Based on the current evidence to date, research on RMBDs does not show a clear benefit on the gut microbiome, and may increase the risk of pathogen exposure (Wernimont et al., 2020).

Anecdotes surrounding RMBDs include that they have anti-inflammatory and/or anti-oxidative effects as they theoretically contain higher levels of antioxidants and lower levels of heterocyclic amines (HAs). HAs are produced

when muscle meat is cooked at a higher temperature such as during the production of meat-based kibble diets. Furthermore, those who choose RMBDs often claim that these diets are nutritionally superior and provide many benefits such as a shiner coat and improvement in energy and immunity. Unfortunately, many of these health benefit claims have not been scientifically evaluated and therefore remain unproven. Moreover, there exist many risks associated with feeding RMBDs.

First, upon evaluation, many commercial RMBDs have had nutritional imbalances such as incorrect calcium to phosphorus ratio (Stogdale, 2019). This is especially true for those produced by small companies avoiding synthetic nutrient supplements. Many RMBDs are also high in fat—while potentially leading to coat improvements, higher fat diets can also cause gastrointestinal issues and increase the risk for obesity as they are easy to overfeed due to increased palatability. Third, RMBDs that require the addition of bones, pose a risk for intestinal obstruction and/or perforation.

Next, due to the nature of raw diets, they are inherently prone to bacterial contamination. In fact, reports of raw meat pet food containing zoonotic foodborne bacteria, including *Salmonella*, *Escherichia coli*, and *Listeria monocytogenes*, are increasing (Jones, 2019). While many dogs may tolerate pathogens, others succumb to illness, and some have even died due to infection with pathogens in their raw food diets. Prevalence rates for contamination with *Salmonella* in commercial RMBDs ranges from 20% to 48% (Freeman, 2013). As for other pathogenic bacteria, according to a report published by Public Health England in 2017, of four individuals (one of which died) infected with multidrug-resistant (MDR) *E.coli* O157, three were feeding a raw commercial frozen diet to their dog (Byrne et al., 2018). All were positive for shiga toxigenic *E.coli*, and in one case the bacteria was cultured out of the freezer. This clearly demonstrates that although freezing and freeze-drying may reduce the number of bacteria, it does not destroy all pathogens. These pathogens will continue to be shed in the feces even if the dog consuming the RMBD does not show signs of illness. This poses a risk for humans who come into contact with the dog, especially people who are young, old, pregnant or immunosuppressed. Another human health risk associated with feeding RMBDs is exposure to resistant bacteria which can provide a source of antibiotic resistance in humans. Several studies published in the United Kingdom and the Netherlands have provided clear and compelling evidence that dogs fed RMBDs are shedding significantly more antibiotic-resistant bacteria than those fed cooked diets (Baede et al., 2017, Wedley et al., 2017, Schmidt et al., 2015).

Based on overwhelming scientific evidence, The American Veterinary Medical Association and the American Animal Hospital Association oppose

the unregulated feeding of raw foods and discourage “the feeding to cats and dogs of any animal-source protein that has not first been subjected to a process to eliminate pathogens, because of the risk of illness to cats and dogs, as well as humans” (AAHA.org, AVMA.org).

Aside from the risks posed by meat-based kibble diets mentioned earlier in the chapter on Dog Food Evolution and Safety, such as the use of rendered products and the presence of toxins including euthanasia drugs, meat-based kibble diets are also prone to bacterial contamination. In fact, there have been over 180 dog food recalls since 2009, with some of the major ones from bacterial contamination of meat sources used in meat-based kibble.

Earlier I also mentioned that kibble was made using the same process used to make breakfast cereals, high heat extrusion. During this process, wet and dry ingredients are mixed together to form a dough. The dough is then cooked under high pressure and high temperature and pushed through a machine to cut the kibbles. The kibble is then dried, cooled and spray coated. On the surface this process seems benign—after all, who doesn’t love cereal? However, the problem lies in what happens to the meat when it is subjected to high temperature. Heterocyclic amines are compounds formed when muscle meat is cooked at a high temperature, and have been associated with cancer in research animals when consumed in high concentrations (Sugimura et al., 2004). It is important to note here that while heat processing of moist or dry extruded pet foods may have a negative impact on animal tissue proteins, heat processing improves the bioavailability of some plant proteins.

As for the benefits of meat-based kibble diets, these diets have the most amount of research behind them because the largest companies in the pet food industry make mostly meat-based kibble and have the money to fund studies including feeding trials to support nutritional adequacy. Furthermore, these diets offer convenience to pet parents, while also usually being lower in cost when compared to both RMBDs and plant-based kibble diets. Proponents of feeding meat-based kibble also claim reduced dental tartar and improved gum health. While this claim is supported by research, kibble size does matter (and this likely applies to plant-based kibble diets as well). A study published in 2007 concluded that increasing the kibble size by 50% resulted in a 42% decrease in the accumulation of dental tartar (Hennet et al., 2007).

Plant-based diets are inherently free of many of the risks associated with RMBDs and meat-based kibble diets described above. They are also free of the most commonly reported food allergens for dogs, making them a great option for dogs with food allergies, and why many food-allergic dogs have experienced symptom relief on plant-based diets. Plant-based diets also offer many other benefits, and when compared directly to conventional meat-based kibble and RMBDs, a recent study found that “the pooled evidence to

date indicates that the healthiest and least hazardous dietary choices for dogs are nutritionally sound plant-based diets” (Knight, 2022). In the following chapter I will dive into this study as well as additional research that supports plant-based feeding in dogs.

The Research Supporting *Plant- Based Diets* for Dogs

“Dog longevity was reported to be greater for dogs fed plant-based diets.” (Dodd et al., 2022)

So why choose a plant-based dog food when there are so many other dog foods on the market? Well, there are a variety of reasons which include the overall health and wellbeing of your patients, allergy support, meat quality concerns, the environment and farm animal welfare.

Let’s start with health, because after all, that is our greatest concern as veterinary professionals. As I mentioned earlier, the most common culprits involved in cutaneous adverse food reactions in dogs are beef, chicken, and dairy, which plant-based diets are inherently free of.

Aside from allergies—while historically there has been a lack of evidence supporting plant-based feeding in dogs, there has been an explosion of research in the past several years demonstrating the value of plant-based diets for dogs.

Before diving into the more recent research, a foundational study conducted in 2009 is worth mentioning. Interestingly enough, most commercial meat-based kibble dog foods typically contain a high proportion of plant ingredients, as a high grain content is necessary for successful extrusion. It is only a small step from some of the popular cereal-based dry dog foods to one that contains no meat at all. Conceptually, however, the gap is much larger, and so a group of researchers set out to develop a nutritionally complete and balanced plant-based diet, and to demonstrate its nutritional adequacy by feeding the diet in a controlled experiment to active dogs (Brown et al., 2009). Since exercise places additional demands on the body, it was thought that dogs fed a meat-free diet may be at increased risk of developing sports anemia. They used a group of 12 sprint-racing sled dogs and fed them either a commercial diet recommended for active dogs, or a meat-free diet formulated to the same nutrient specifications. Blood samples were collected at weeks 0,

3, 8 and 16, and veterinary health checks were conducted at weeks 0, 8 and 16. Blood work results for all dogs, regardless of diet, were within normal range throughout the study, and the consulting veterinarian assessed all dogs to be in excellent physical condition. No dogs in the study developed anemia, and instead red blood cell counts and hemoglobin values increased significantly over time in both groups of dogs. This study showed that a carefully balanced meat-free diet could provide all the nutrition dogs need, even very active dogs. Since this foundational study, research has continued to emerge supporting plant-based feeding.

In 2016, a group of researchers investigated the evidence from four previously published studies that examined the nutritional soundness of plant-based commercial diets and the health status of dogs maintained on vegetarian and meat-based diets (Knight, 2016). The authors concluded that it is entirely possible for companion animals to thrive on vegetarian diets, but these must be nutritionally complete and balanced.

In a separate study published in 2021, authors assessed the short-term amino acid, clinicopathologic, and echocardiographic findings in healthy dogs fed a commercial plant-based diet (Cavanaugh et al., 2021). Thirty dogs fed a commercial extruded plant-based diet using pea as the main protein source, were compared to a non-randomized control group of 4 dogs fed different brands of commercial extruded meat-based diets. Plasma amino acid concentration and whole blood taurine concentration were measured at baseline and after 4 weeks of being fed either diet. Plasma and whole blood taurine, as well as all essential amino acids, except methionine, were higher in dogs fed the plant-based diet compared to baseline. These findings suggest that plant-based diets can be formulated and processed to achieve taurine and other nutrient targets in dogs.

Hematologic and serum biochemical testing, namely a complete blood count, serum chemistry and urinalysis were also performed at baseline and after week twelve of being fed either diet, and were within normal limits. As for the urinalysis results, there was an increase in urine pH in the PBD group, which is not unusual as plant-based diets in humans have been shown to increase urine pH and reduce the risk of certain urinary diseases. Lastly, echocardiographic testing was also performed at baseline and after twelve weeks. There was no statistically significant difference between the dogs fed either diet at baseline or at 12 weeks, with no evidence of overt left ventricular systolic dysfunction in either group.

The results of this study indicated that the health of the dogs was maintained and did not deteriorate after 12 weeks on a plant-based diet. As with traditional diets, not all plant-based diets are equal since composition and nutrient availability vary based on formulation and processing so it is im-

portant to choose a nutritionally complete and balanced diet to recommend to your patients. Further research is needed to elucidate the potential long-term effects of PB diets on health and disease in dogs. Spoiler alert: A long-term study was published in early 2023.

In regards to the manufacturing of plant-based diets, a study demonstrated that upon review, plant-based diets were seen to have been produced at equal or superior standards to meat-based diets, with acceptable or superior standards overall at all stages of formulation (Knight et al., 2021). Not only can commercially available plant-based diets be of high quality and be healthy, but they can also be delicious and satisfying to dogs. In 2021, a group of researchers from the University of Winchester surveyed the owners of 2,308 dogs (and 1,135 cats), and found that those who were fed plant-based diets for at least one year were just as eager to eat and just as healthy as those fed meat-based diets (Knight & Satchell, 2021).

In 2022 alone, three new survey-based studies were published—all which suggest that a plant-based diet may be healthier for some dogs than conventional diets and promote longevity for our patients. The first of these compared owner perceptions of health for dogs fed meat-based vs. plant-based diets. 1,189 dogs were included in the study—665 who ate meat-based diets and 339 who ate plant-based diets for an average of three years (Dodd et al., 2022). The authors concluded that the owners of dogs who were fed plant-based diets “reported fewer health disorders, specifically with respect to ocular, gastrointestinal and hepatic disorders”. Dog longevity was also reported to be greater for dogs fed purely plant-based diets, with purely plant-based dogs reportedly living 1.5 years longer than dogs fed meat. The reported differences were statistically significant (Dominguez-Oliva et al., 2023).

The second of these studies evaluated the health perception of 100 pet guardians who fed their dog a plant-based diet, and found that dogs who were fed plant-based dog food found the food palatable, with no adverse changes in appetite or weight (Davies, 2022). Changes, including health improvements, after 3–12 months were also reported in body condition score, activity, coat glossiness, dandruff, skin inflammation, pruritus, external ear canal crusting, fecal consistency, defecation frequency, flatus frequency, flatus antisocial smell, anxiety, aggressive behavior and coprophagia.

Lastly, the third of these peer-reviewed studies included over 2,500 dogs, and revealed that dogs who eat a well-balanced plant-based diet require less medication, visit the vet less frequently, and suffer from fewer health disorders according to their owners when compared to dogs who eat conventional meat-based diets—suggesting that a plant-based diet may be healthier for some dogs (Knight et al., 2022). The authors concluded that the pooled ev-

idence to date indicates that the “healthiest and least hazardous” dietary choices for dogs are nutritionally sound plant-based diets.

It is important to remain mindful of the fact that the results of these three studies were based on the opinions of owners, however, that applies to all groups of owners, and these results might suggest an association between feeding a plant-based diet and perceived health and longevity.

Several of these studies were also included in a literature review published in 2023 that analyzed the health impacts of a plant-based diet in cats and dogs using established methods of evidence synthesis (Domínguez-Oliva et al., 2023). The authors identified 16 scientific studies (1992–2022) that met their criteria—dogs or cats in a domestic setting fed a vegan or vegetarian diet with outcomes related to animal health, physiology or welfare measures. Eligible studies were critically appraised for methodological quality, and underwent data extraction and synthesis. For canines, twelve studies examined outcomes in dogs fed plant-based diets—nine of those measured outcomes directly and four used guardian reports on health outcomes or perceptions of health. The results demonstrated that the majority of the objective animal-based parameters were within normal reference ranges, and for those that deviated from normal, there were rarely clinical signs reported alongside the finding. Further, while there are commonly references in the broad literature to concerns around nutrient deficiencies, there is limited evidence of these deficiencies arising, and in most instances confounding factors were present. The authors concluded that there is no overwhelming evidence of adverse effects resulting from the feeding of vegan diets to dogs (or cats), and that there is evidence of benefits. Because many of these studies were either short in duration and/or based on the opinions of owners, there exists a need for future high-quality, randomized, controlled studies, with standardized outcome measures, large sample sizes, and longer duration.

With this need identified, a group of clinician-scientists from Western University published the longest and most comprehensive study on plant-based feeding in dogs to date (and therefore of course, the most meaningful study to us scientists). Fifteen clinically healthy dogs were fed a complete and balanced plant-based diet for a year (Linde et al., 2023). Clinical, hematological, and nutritional parameters were evaluated at 0, 6 and 12 months, including complete blood count, serum chemistry, cardiac biomarkers, plasma amino acids, and serum vitamin concentrations. Comparative analysis of blood work and urinalysis showed no clinically significant changes between baseline, intermediate, and endpoint values. Furthermore, CBC and blood chemistry values remained within normal reference ranges throughout the study.

A common misconception regarding plant-based diets is that they provide less protein than traditional meat-based diets (which we know is untrue). The researchers further busted this myth by measuring the levels of essential amino acids—all of which were within or above normal reference ranges, with an upward trend. L-aurine (plasma) and L-carnitine (serum) levels were also measured due to their importance to myocardial health and the fact that both have been used as nutritional supplements in reference to canine dilated cardiomyopathy (DCM). A statistically non-significant increase in these nutrients was observed when comparing baseline to endpoint values.

As mentioned, concentrations of vitamins were also evaluated. A very interesting and positive finding was seen with vitamin D. Seven dogs presented with vitamin D insufficiency as a result of eating a meat-based diet prior to the start of the study, and after six months of eating a plant-based diet, only one dog was insufficient—and by 12 months all dogs had normal vitamin D levels. As for vitamin A, concentrations stayed within the reference range and exhibited an upward trend. Vitamin E levels were more than adequate throughout. Lastly, as for B vitamins, folate was below the reference range in six dogs at the outset of the study and by 12 months only three of those dogs had low folate. Cobalamin was within the normal reference interval at all three time points.

In order to evaluate heart health, cardiac biomarkers Cardiac troponin I (cTnI) and NT-proBNP were measured at the three time points, and not only did they maintain within reference ranges, but there was a downward trend in both. Furthermore, cTnI levels were increased in three dogs at baseline, compared to only one dog at endpoint.

Also interesting to note, the body weight of the dogs remained stable, while body condition scores trended downwards in overweight/obese dogs. Plant-based diets have long been correlated with a healthy body weight and this data serves to further support that. As we know, dogs at a normal body weight live on average two to two-and-a-half years longer than overweight/obese dogs (Salt et al., 2019).

Given the results, the authors concluded that health was maintained after 12 months of being fed a commercial plant-based diet.

This study surpassed AAFCO feeding trial guidelines, which recommends a minimum study period of six months and only eight dogs with health exams performed by a licensed veterinarian and assessment of four blood parameters including hematocrit, hemoglobin, albumin, and alkaline phosphatase.

Not only are plant-based diets able to meet the nutritional needs of dogs, and are associated with fewer health disorders and increased longevity, but they also address concerns regarding farm animal welfare and environmental sustainability.

Conclusion

While helping to save the environment and protecting countless animals from suffering and slaughter certainly have merit, canine health is at the forefront when determining what to feed our own dogs and what to recommend for our patients. After all, nutrition is the fifth vital assessment, right next to temperature, pulse, respiration, and pain—which highlights just how important it is. In this book I have provided evidence supporting plant-based diets in dogs; and it is my hope that you have come to see that a plant-based diet can be nutritionally complete and balanced given it is carefully formulated, digestible, and bioavailable. By no means am I suggesting that all plant-based diets are nutritionally sound, and therefore I urge you, as a scientist and your patient's biggest advocate, to think critically when evaluating a diet.

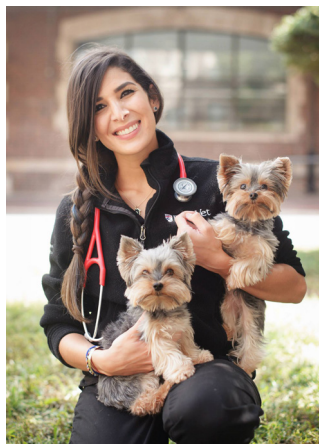
It is important to remember that there is an abundance of misinformation that often goes against the science-based evidence, and as veterinary professionals we are not immune to it. Complete and balanced plant-based diets should be given equal consideration to meat-based diets, especially given the current understanding of pet nutrition, and the emphasis on nutrients not ingredients. Currently, meat-based diets are evaluated based on whether they meet AAFCO requirements for nutritional sufficiency and plant-based diets should be evaluated using the same criteria.

My goal in writing this book was to arm you with accurate and up to date information so that you feel able to take the best steps towards making more educated decisions regarding pet food. A nutritionally complete and balanced plant-based diet can meet the nutritional needs of dogs, and help dogs live healthier and longer lives—all in a sustainable and cruelty-free way.

“Given the current understanding of nutrition and emphasis on nutrients not ingredients, plant-based diets should be evaluated using the same criteria used for meat-based diets - whether they meet AAFCO requirements for nutritional sufficiency.”

– Tiffany Ruiz Dasilva, VMD, cVMA

About the *Author*



“Like most of us, I’ve wanted to become a veterinarian since I can remember. I knew from a very young age that I wanted to do all I could to help animals.”

Dr. Tiffany Ruiz Dasilva is a creative, versatile, passionate, and enthusiastic veterinarian with expertise in canine nutrition. Her areas of interest include animal nutrition, behavior, pain management and pet parent education, with the overarching goal of improving the human-animal bond. She received her Bachelor of Science degree in Biology with a focus on Brain and Behavior from Brown University.

Following graduation, she lived in Africa, working in wildlife conservation and rehabilitation, helping to prepare diets and care for sick, orphaned, and injured wildlife. She received an academic scholarship to attend veterinary school at the University of Pennsylvania, completing research in genomics and diabetes at the Children’s Hospital of Philadelphia.

Following graduation, Dr. Ruiz Dasilva worked in general practice, on telehealth platforms, and received her Fear Free certification, which aims to prevent and alleviate anxiety and stress in the animals she cares for.

In 2020, in response to the lack of access to veterinary care during the pandemic, she created an affordable, multilingual telehealth platform in an effort to make veterinarians more easily accessible, and, in turn, provide pet parents with factual information to optimize their pet’s health. As accessibility to in person care returned, she channeled her passion for improving the human-animal bond into pursuing a certification in acupuncture and began working at a rehabilitation practice. It was during this time, coupled with her previous experiences, that she continued to realize the immense importance of nutrition in chronic disease and overall health, leading her to pursue the position of veterinarian at Wild Earth, a plant-based pet food company.

She has gained expertise in the field of nutrition through numerous certifications and coursework, and believes that lifelong learning and question-

ing is key. She has worked tirelessly to compile the evidence for plant-based feeding in dogs, has spoken to leading experts in the field, and has come to see the benefits of a plant-based diet for longevity and symptom relief for many dogs. As part of her role at Wild Earth, Dr. Ruiz Dasilva advises at all stages of product development, product formulation and feeding guidelines, presents at conferences, and helps to educate pet parents and veterinarians.

“It is my mission to educate both pet parents and veterinarians alike on the importance of nutrition, and how a nutritionally complete and balanced plant-based diet can meet the nutritional needs of dogs in a sustainable and cruelty-free way. My goal is to provide evidence-based data to those who seek it, and to be a reliable source of information to help dogs live longer, healthier, and happier lives.”

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