PEER REVIEWED

Plant-based Diets for Dogs: Separating Fact from Fiction

Recent advances in biology and veterinary nutrition are challenging the long-held assumption that dogs require conventional animal meat to thrive. There is increasing evidence to suggest that the nutrients domestic dogs require no longer need to come exclusively from the flesh of other animals. This article explores how modern-day pet dogs have biologically adapted to receive essential nutrients, in bioavailable form, from plant-based food. It discusses the evidence that plant-based diets may be healthier for dogs than animal-meat-based foods, and addresses the obstacles preventing owners from switching to plant-based feeding. Calling for further longitudinal, large-scale studies that verify the benefits of plant-based diets for dogs and more education on plant-based nutrition in the veterinary profession, it concludes with an overview of the pet food companies creating complete animal-free diets for dogs today.

Nutritional Requirements of Domestic Dogs

Protein is essential for canine health, helping grow and maintain muscle, hair, and connective tissues, transporting nutrients throughout the body, synthesising hormones, and supporting the immune and neurological systems. The minimum amount of dietary protein required for canine growth is 22.5 per cent of daily food consumption (NRC) and the Association of American Feed Control Officials (AAFCO) requires dry food for adult dogs to contain at least 18 per cent protein. The food must also be proven to contain *bioavailable* nutrients, that can be digested and absorbed within the body. Protein molecules are "strings" comprised of amino acids, which are broken down by the dog's digestive system. Ten of these amino acids are classified as essential nutrients for dogs, or amino acids they must consume in their diet to live. The 10 canine essential amino acids are: arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. A nutritionally complete dog food must contain all of these 10 amino acids in adequate levels. The canine body uses these essential amino acids to synthesise the remaining required 12 amino acids, including taurine and carnitine.

Can Dogs Get the 10 Essential Amino Acids from Plant-based Food?

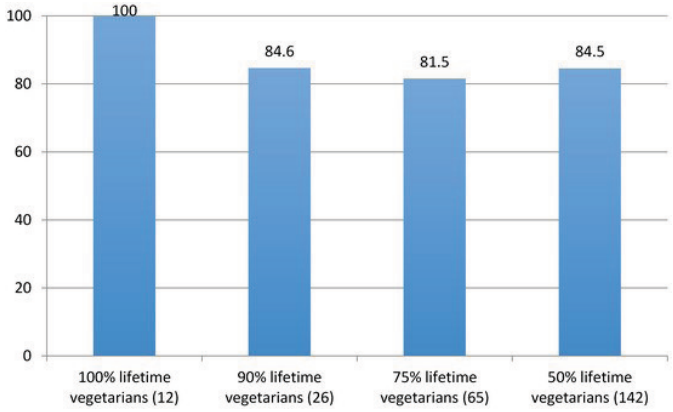
High quality plant, yeast, bacterial, or algal protein sources can, and do, contain all 10 essential amino acids for dogs. It is common in pet food marketing to portray domestic dogs as 'miniature wolves' that must consume their 'natural' meal of animal flesh. However, canine mitochondrial DNA (mtDNA: genetic material passed from mother to puppy) gives us a different understanding of canine evolution. Canine mtDNA analysis proves that dogs began to phylogenetically diverge from grey wolves between 15,000 and 40,000 years ago. The most common evolutionary theory proposes that as the boldest, friendliest wolves secured the most scraps from the caveman's camp, these fierce animals became 'tame', humans benefiting from the protection offered by their canine associates. These 'friendly and collaborative' or 'trainability' traits were transferred to offspring and amplified later through selective breeding and domestication. Archaeological evidence suggests that as far back as 11,500 years ago, humans and dogs likely hunted animals collaboratively (Yeomans *et al.*, 2019). Many thousands of years later through hundreds of generations, dogs and humans have biologically adapted to become more similar in terms of social communication, energy requirements, temperature adaptation, behaviour, and, most significantly, dietary requirements.

As domestic dogs coevolved with humans, their biology adapted in terms of both physical features and internal functionality. In 2013, researchers conducted whole-genome resequencing of dogs and wolves and identified 36 key genomic regions associated with canine domestication (Axelsson *et al.*, 2013). Ten of the adapted dog genes were responsible for changes in starch digestion and fat metabolism: specific genetic mutations that have allowed dogs to digest and metabolise the starches in plant-based foods far more efficiently than wolves. A second paper confirmed that dogs have more copies of a gene called AMY2B than wolves. This gene is crucial for producing *amylase*, a primary enzyme involved in starch digestion. In dogs, amylase activity is around 30 times higher than in wolves. Further validating the domestic dog's biological adaptation for starch digestion is the presence of a longer version of the amylase gene that produces *maltase*, another key enzyme required for starch digestion (Arendt *et al.*, 2014) and found in herbivores and omnivores. More recent research discovered that dog populations 7000 years ago in South Eastern Europe and Southwest Asia also contained duplications of the AMY2B gene (Ollivier *et al.*, 2016), allowing dogs in the region to thrive on a plant-rich diet, especially within early farming societies. The evidence

is mounting that domestic dogs have been thriving as omnivores for thousands of years. Further nutritional distinctions between dogs and carnivores such as felids (cats) is the fact that dogs can convert plant-based beta-carotene, also known as "provitamin A", to retinol, the "pure" or biologically-active form of vitamin A. Cats cannot make this conversion and must obtain retinol either from animal sources or supplements. Dogs can also convert linoleic acid, an omega-6 fatty acid found in plant-based sources, to the essential arachidonic acid, while carnivores are unable to make this conversion.

Increasing Evidence for Healthy Plant-based Dogs

In 2016, Knight and Leitsberger published an article in the journal *Animals* entitled "Vegetarian versus Meat-Based Diets for Companion Animals" which provided convincing evidence that dogs fed a nutritionally complete plant-based food can thrive. That article has been downloaded about 20,000 times, the second highest in the history of the journal, suggesting significant interest in the topic. In fact, a number of scientific studies now support animal meat-free pet diets. Over 25 years ago, the organisation People for the Ethical Treatment of Animals (PETA) published the results of a systematic survey of the health of 300 vegetarian dogs sourced from 33 US states and Canada (PETA, 1994). These dogs, representing a wide range of ages and breeds, were maintained on animal meat-free diets for two to over nine years, with an average being fed plant-based food for 5.7 years. Over 80 per cent of dogs maintained on vegan or vegetarian diets for 50 to 100 per cent of their lifetimes were documented as being in "good to excellent health". The few health problems found were those also commonly reported within the animal-meat-eating dog population, such as obesity, skin infections, and arthritis.



Percentages of dogs in good to excellent health, vs. time as vegetarians (PETA, 1994)

This was scientifically rigorous research, providing adequate numbers of animals for the results to be reliably extrapolatable to the wider population. More recently, a 16-week study of 12 sprint-racing Siberian huskies (Brown *et al.*, 2009) evaluated the health and performance of six of the canine athletes fed a commercial meat-based diet and six on a vegetarian diet. Both diets used in the study were formulated to the exact same nutritional composition and were the dogs' sole nutrient source for the four-month study, which included a period of intensely competitive racing. All the dogs appeared to be extremely fit and there were no adverse effects reported for the huskies fed a vegetarian diet. Despite the small number of dogs in this study, these findings suggest that plant-based canines can thrive even when undergoing intense and prolonged physiological demands.

Other anecdotal cases show pets on plant-based diets may have increased overall health and vitality; decreased incidences of cancer, infections and hypothyroidism; improved coat condition; fewer allergic conditions; lower rates of obesity; decreased arthritis; and diabetes remission. In 2009, a veterinary publication on vegetarianism in the domestic dog concluded that as long as the animal-meat-free diet is correctly formulated to meet nutrient requirements and is sufficiently palatable to ensure adequate dietary intake,

Iditarod Trail Sled Dog Race 2010

"then it is a suitable diet for the dog, irrespective of the owner's motivation for feeding a vegetarian diet" (Brown, 2009).

Is a High Animal Protein Diet Healthy for Domestic Dogs?
With raw meat pet diets soaring in popularity, there is a widespread belief that high-protein animal flesh is the healthiest diet for dogs. However, high-animal-meat diets are generally high-calorie diets, leading to weight gain and obesity. Feeding pet dogs high-meat meals as if they were wolves is a fallacy, given that wolves burn about 70 per cent more calories a day compared to domestic dogs. Wild wolves may roam up to 50 miles before finding or killing a meal, yet surveys indicate that most domestic dogs are walked less than 30 minutes a day. The Association for Pet Obesity Prevention (APOP) finds that more than half of all US dogs and cats are overweight or have obesity, placing them at elevated risk for weight-related disorders including diabetes, arthritis, hypertension, kidney disease, and cancer. Bramble, a blue merle Collie in the UK, once held the Guinness World Record for being the "oldest living dog" at 27 years of age. She lived on a strict plant-based diet of rice, lentils, and organic vegetables and nutritional yeast, eating once a day and exercising regularly. In stark contrast to Bramble's outstanding health and longevity, the American Veterinary Medical Association (AVMA) estimates over half of all dogs will develop cancer after age ten. Most scientists put the contribution of inherited genetic mutations at about five to 10 per cent of an individual's risk of developing cancer. The vast majority of cancers are believed to be caused by environmental contributors, including the potential long-term impact of the food our pets consume throughout their life. Dogs and cats are being exposed, over many years, to toxins not severe enough to cause acute reactions, but sufficient to cause hidden cellular damage. Veterinarians such as Knight (2020) believe many of these toxins come from factory-farmed animals and contemporary animal meat processing.

Although studies proving the long-term safety of either meat-based or plant-based diets for pets are still relatively few, those showing that vegetarian pet diets are less healthy than animal-meat pet food are even more lacking. In fact, Knight points to at least 11 academic studies showing that animals fed various animal-protein diets suffer with a variety of health conditions over time (Knight, 2020). Diseases documented to be more likely when cats and dogs eat commercial animal-meat-based diets include those affecting the kidneys, liver, heart, thyroid, neurological system, neuromuscular structure, and the skin, as well as leading to infectious diseases and bleeding disorders. Only one study (Bednar *et al*., 2000) compared the nutrient digestibility and faecal characteristics of dogs fed animal- and plant-protein sources and concluded that digestibility of the plant-based dog food was marginally lower than the animal-protein food. Yet only four dogs were included in that study, and the researchers stated that all diets were "well utilised" by the dogs in terms of digestibility and faecal characteristics.

Meat-based dog treats on sale in the UK. Photograph by David Wright, CC by 2.0

Animal proteins are also the leading cause of food sensitivities in dogs. A recent study revealed that animal-based ingredients were responsible for 236 cases of food allergies in dogs. By contrast, plant-based ingredients were responsible for only 77 cases (Mueller *et al*., 2016). Eight out of ten of the top allergens in pet foods are animal products (Pitcairn and Pitcairn, 2017). Many veterinary therapeutic dermatologic or "prescription" diets are made without any animal meat to reduce their allergenicity. Plant-based diets such as Purina HA Vegetarian Canine Formula is formulated "to be less likely to cause an adverse food reaction in certain dogs". Royal Canin advertises their Canine Vegetarian Dry Dog Food "for dogs with food sensitivities". Some of the most effective protein sources for preventing and treating canine food allergies are plant-based, and an animal-free diet can be a remedy for other common allergies or inflammatory conditions, such as inflammatory bowel disease (IBD).

Why are Plant-based Dog Diets Still Controversial?
In the past, nutritionally complete-and-balanced plant-based pet foods have been hard to find. Vegan dog foods such as Halo, V-dog, Natural Balance, and a few other small pet food companies haven't been available at most large pet retailers or grocery stores. Animal-free pet foods can also be expensive. Producing an affordable plant-based dog food could be a lucrative ambition for pet food companies. However, there is an even bigger challenge: public perception. Pet owners are bombarded with marketing messages from major pet food producers insisting that feeding a meat-based diet is best, and that they will somehow deprive their dogs by omitting animal flesh. In 2019, Dodd et al. surveyed 3673 dog owners and found that vegans were the only owners who omitted meat from their pets' diets (plus one vegetarian). Of the vegans surveyed, only 27 per cent (58 of 212) reported feeding their dog a plant-based diet. Yet 78 per cent of vegan pet owners indicated they *would* feed a meat-free diet to their pet if one were available that met their required criteria. Indeed, 35 per cent of *all* survey respondents (N= 1083) who did not already feed a plant-based diet to their pet indicated interest in doing so, provided they received further evidence of nutritional sufficiency, veterinary approval, and greater availability.

Despite the growing evidence base cited here and the growing number of complete-and-balanced AAFCO- and FEDIAF-approved plant-based pet foods, more longitudinal, large-scale studies are needed to convince both the public and the veterinary industry of the long-term safety of plant-based feeding. Veterinary recommendation is a key factor in owner feeding habits, and there is currently little veterinary nutritional education on plant-based canine diets. Owners whose dogs are thriving on meat-free diets are quick to advocate the practice, but anecdotal evidence is not a substitute for rigorous academic studies.

Do Dogs *Like* Plant-based Food?
Many dog owners worry that they will be depriving their dog by removing animal meat from their meals. It is true that until recently, most commercial plant-based dog foods focused

on nutritional completeness and balance rather than flavour. However, the perceived blandness of vegetarian pet foods is changing as new protein sources and production techniques advance, with new startups producing appealing savoury flavours from koji and yeast, as well as tasty peanut-butter or sweet potato treats. Furthermore, owners should be careful not to confuse canine concepts of edible or palatable with their own human concept of what is 'tasty'. The images of succulent beef, juicy chicken breasts and fresh-caught salmon that line pet food aisles are designed to appeal to the tastes of pet owners, not their pets. The reality is that the kibble or wet food inside the packaging bears little resemblance to these pictures. Meat-based pet food companies typically enhance the palatability of their dry pet foods for dogs and cats by spraying them with "digest", the entrails of chickens and other animals. Philadelphia startup Because Animals are working on an animal-free palatant as an alternative, and many new meat-free pet food companies are creating products that taste delicious to dogs without any artificial enhancement.

Who Are the Plant-based Pet Food Companies to Watch?

Because Animals is a new pet food company working on creating plant-based treats. Their dental cookie for dogs is made of chickpea flour, nutritional yeast, chia seeds, and kelp: the latter ingredient is rich in iodine with high levels of other nutrient minerals and vitamins. California startup Wild Earth also have animal-free pet food on the market, their peanut butter-flavoured dog snacks combining flax, oats, and green tea with koji, an ancient mushroom superfood, which contains all 10 of the amino acids that dogs require. Their animal-free, complete and balanced dog food contains over 30 per cent protein. Meanwhile, established brands like V-dog, Benovo, Halo, Wysong, and Natural Balance plant-based pet foods are becoming more readily available. In Europe, Green Petfood and Ami Pet Food are creating vegetarian and vegan pet foods that, as Ami Pet Food puts it, pave the way for "an ethical, eco-friendly and successful economy". In the UK, three times as many vegetarian pet foods were launched in 2014 as in the previous three years (Knight and Leitsberger, 2016). In March 2019, 16 global leaders in plant-based veterinary nutrition and science contributed presentations to the world's first "The Plant-Powered Dog Food Summit", created for people interested in learning more about feeding their dog a plant-based diet. For this growing market of conscientious consumers, there is a wealth of new innovative plant-based canine pet foods out there: they just need to be convinced to try them.

A selection of plant-based dog treats, food and supplements already on the market

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Alice Oven

Alice Oven is co-author of The Clean Pet Food Revolution: How Better Pet Food Will Change the World, with Ernie Ward and Ryan Bethencourt. She is a freelance animal ethics writer and Senior Editor for Veterinary and Life Science books at Taylor & Francis Publishing. Alice is researching pet owner attitudes to feeding cell-based meat as part of her MSc Animal Welfare Science, Ethics and Law at University of Winchester.

Email: aliceoven@gmail.com

Dr. Ernie Ward

Dr. Ernie Ward, "America's Pet Advocate" is an internationally recognized veterinarian, author, and speaker. He is known for his innovations in general small animal practice, nutrition and pet obesity, and advocating for the special needs of senior dogs and cats. Dr. Ward is co-founder and Chief Veterinary Officer for Wild Earth a plant-based sustainable pet food company based in Berkeley, California.

Email: ernie@wildearth.com