Pet Food Safety: Dietary Protein

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The goal of this article was to review the evidence surrounding the risks posed by insufficient or excessive dietary protein. Dietary protein is required to provide essential amino acids and replenish protein reserves. When intake is deficient, protein turnover slows and lean body mass is gradually depleted. These changes lead to increased morbidity and mortality. Dogs can maintain nitrogen balance (typically used to define minimum requirements in adults), yet be in a protein-depleted state due to physiologic adaptations. Preservation of protein turnover and lean body mass requires about threefold more protein than nitrogen balance. The ability of excess dietary protein to induce renal pathology was studied in both dogs with chronic kidney failure and older dogs without kidney failure. Numerous studies have confirmed that protein does not adversely affect the kidneys. However, phosphorus- and protein-restricted diets are clinically beneficial in dogs with existing chronic kidney failure. Protein restriction for healthy older dogs is not only unnecessary, it can be detrimental. Protein requirements actually increase by about 50% in older dogs, while their energy requirements tend to decrease. When insufficient protein is provided, it can aggravate the age-associated loss of lean body mass and may contribute to earlier mortality. Older dogs should receive at least 25% of their calories from protein, typically provided by diets containing at least 7 g protein/100 Kcal ME.

Dietary protein has been the subject of controversy in veterinary nutrition for decades. Among the issues are concerns about the safety— or lack thereof— of excessive or restricted protein intakes. The goal of this article was to review the evidence surrounding this issue.

Remembering the Basics: Protein Metabolism

Dietary protein is predominantly a source of essential and nonessential amino acids. All proteins, whether dietary or endogenous, are made from the same 20 alpha amino acids. Ten of these, the *essential amino acids*, must be provided in the diet. The other 10 also are essential to the body for normal protein metabolism, but these can be produced endogenously via transamination, so are not considered dietary essentials. In addition to these, the beta amino acid taurine— which is not incorporated into proteins—is an essential nutrient for cats and conditionally essential for dogs.

Endogenous proteins serve numerous roles in the body (Table 1). Each protein has a finite lifespan and must be replaced as needed. Synthesis of each protein is directed by RNA and requires the availability of all necessary amino acids. The primary source of these amino acids is the catabolism of endogenous proteins in the lean body mass

(LBM).[1–3] The ongoing process of protein catabolism and synthesis of new proteins is referred to as *protein turnover* (Fig. 1). Dietary protein provides only a fraction of the amino acids used each day but is critical to replenish the system. Protein turnover is sensitive to protein intake and slows in response to inadequate dietary protein.[1-5] Over time, consumption of deficient or marginally deficient protein diets will result in loss of LBM despite a reduction in protein turnover.[2,3]

What Are Minimum Protein Requirements?

Minimum nutrient requirements are defined as the lowest intake that will support normal function, such as maximal growth rates or prevention of deficiency signs. The minimum protein requirement for adults is typically defined, using a nitrogen balance study, as the smallest amount of a good quality protein that will maintain the subject in positive nitrogen balance after they have been allowed to accommodate to a low protein intake.[3,6] However, nitrogen balance does not account for changes in LBM.[1,3]

Endogenous proteins from the liver and gastrointestinal tract are utilized first to support protein turnover during short periods of protein deficiency, while muscle and skin proteins provide the quantitatively largest supply of reserve protein.[1,3] Animals can maintain nitrogen balance yet be in a protein-depleted state.[7] This can be achieved by both a reduction in the rate of protein turnover and the use of protein reserves from the LBM. Reduced protein turnover secondary to inadequate protein intake can lead to decreased immune competence and increased susceptibility to stresses such as

Table 1. Functions of Protein and Selected Examples

Structural	Digestive enzymes
Muscle (actin, myosin)	Lipases
Skin and hair (keratin)	Proteases
Transport proteins	Amylases
Hemoglobin	Cellular enzymes
Albumin	ATPase
Transferrin	Catalases and oxidases
Immune function	Kinases
Antibodies	Receptor proteins
Complement	Source of
Hormones	Energy
Thyroxine	Glucose
Insulin	Amino acids
Glucagon	
Parathyroid hormone	

infection and injury.[4,7,8] While severe protein deficiency typically results in poor food intake and weight loss, subclinical protein deficiency in dogs can result in increased or stable body weight but with an increased proportion of body fat and reduced lean body mass.[9,10] Loss of LBM is associated with increased morbidity and mortality in humans, dogs, and other animals.[3,11-14]

When markers of protein turnover or measures of LBM have been used to study protein requirements, the results differ greatly from that needed to maintain nitrogen balance. For example, in a classic study in young and old beagles, dogs of all ages needed about three times more protein to maintain protein turnover, compared with the amount needed to maintain nitrogen balance.[7] Further, the minimum amount needed by old dogs (about 4 g/kg body weight) was about 50% greater than for young dogs, regardless of which method was used. A similar relationship between methods was seen in cats. Adult cats need more than three times as much protein (about 5.2 g/kg body weight) to maintain lean body mass, compared with that needed simply to maintain nitrogen balance.[15]

What Is the Role of Protein Restriction in the Prevention and Management of Kidney Failure?

The primary concern regarding excess dietary protein has focused on the potential impact on kidney function. It was suggested by Brenner and coworkers that excess dietary protein would cause kidney damage, based on work in rats.[16] While subsequent research suggested that the benefits attributed to protein restriction may have been secondary to the reduced calorie intake associated with low protein diets,[17] the perception that excessive protein intake causes kidney damage remains.[18] As noted below, research in dogs does not support this perception.

The ability of dietary protein to induce renal pathology was studied in both dogs with chronic kidney failure and older dogs without kidney failure. One study, undertaken to

contrast the potential renoprotective benefits of protein restriction or phosphorus restriction, compared four carefully controlled diets.[19] The results showed that protein had no adverse effects, even in dogs with kidney failure, although phosphorus restriction did protect against worsening kidney damage. Two other studies evaluated older (age 6 to 8 years at start of study), uninephrectomized dogs that were fed either dry diets containing 18 or 34% protein or canned diets containing 22 or 36% protein, on a dry matter basis, for 4 years.[20,21] No adverse effects from dietary protein were observed in either study. On the contrary, in one of these studies, mortality was slightly higher in dogs fed the lower protein diet.[19] These studies showed that protein consistent with complete and balanced nutrition has no adverse effects on the kidneys of healthy senior dogs.

The authors of a more recent study erroneously concluded that their evaluation showed that increased protein was detrimental to kidneys in healthy older dogs.[22] The basis for their conclusions were changes in serum urea nitrogen and transient differences in microalbuminuria (MA). The authors did show that lower protein intake resulted in lower serum urea nitrogen, but this is a normal physiologic response rather than a marker of renal function. Serum creatinine was unchanged by diet during the 6-month study. They also showed some transient changes in MA that appeared to differ among the diets, although there were no significant differ-
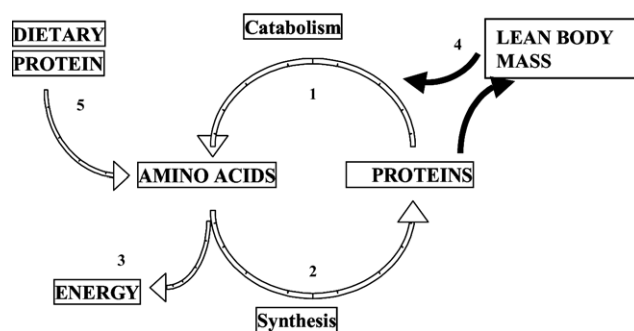

Figure 1. Protein turnover. Endogenous proteins are catabolized (1) to provide amino acids for new protein synthesis. Most of these amino acids are recycled into new proteins (2). Protein synthesis occurs on a continuous basis, translating the messages from DNA/RNA into hormones, enzymes, and other proteins needed by the body. Amino acids not used immediately for protein synthesis are metabolized for energy (3) or transaminated into different amino acids or other compounds. On a daily basis, endogenous proteins and lean body mass (4) provide up to 90% of the amino acids used in protein turnover. If not replenished, this could lead to depletion of lean body mass. Since the recycling of protein and amino acids is not completely efficient, dietary proteins (5) are needed to replenish and maintain the lean body mass. When protein intake is inadequate, the body responds by slowing down this entire process, which helps preserve lean body mass. Over time, however, gradual depletion of lean body mass can be detected when protein intake is not sufficient.

ences in MA in dogs fed an over-the-counter, high-protein senior dog food (Dog Chow Senior, Nestle Purina, St. Louis, MO) and the experimental low-protein, low-phosphorus diet. Further, transient MA is not considered to be of significance unless persistent, and there is no evidence of a renoprotective effect from reducing MA in dogs or cats.[23] Thus, this study further supports the lack of adverse effects of dietary protein on kidneys in healthy, older dogs.

This lack of adverse effects from dietary protein also is being recognized in other species, especially humans. Newer research reevaluating the role of protein as a contributor to kidney disease has found either no effect or a renoprotective effect from increased dietary protein.[24-26]

Even in dogs with existing chronic kidney failure, numerous studies failed to show a clear-cut effect of protein on renal lesions or progression of kidney failure.[19,27-34] On the other hand, dogs with chronic kidney failure have shown a significant clinical benefit when fed phosphorus and protein-restricted therapeutic diets.[35-38] Loss of renal function is associated with an accumulation of a wide variety of nitrogenous and nonnitrogenous waste products of protein catabolism that are thought to be important causes of uremic signs.[39] Because these compounds are derived almost entirely from protein degradation, their production is related to dietary protein consumption. The rationale for reduction of dietary protein in these patients is to reduce production of nitrogenous wastes with consequent amelioration of clinical signs.[39] Multiple studies in patients with existing chronic kidney disease have confirmed a reduction in morbidity and mortality with the use of protein-restricted, low-phosphorus therapeutic diets.[35-38] Dietary protein of ≤18% on a dry basis, or 9 to 16% of metabolizable energy, is recommended to reduce nitrogenous wastes and clinical signs in dogs with chronic kidney failure.[39,40] The reader is reminded, however, that many different nutrients were modified in these therapeutic diets, with phosphorus being of particular concern. While protein restriction may be of benefit in the management of uremic concerns, it appears to be phosphorus restriction that slows ongoing renal damage.[19]

Safety of Protein for Senior Dogs

Many veterinarians have recommended protein restriction for older dogs in the belief that this would help protect kidney function.[18] As identified above, this belief is unfounded. More recent research has unequivocally demonstrated that protein restriction is unnecessary, and potentially detrimental, in healthy, older dogs.[7,20,41,42] On the contrary, protein requirements actually increase by about 50% in older dogs, as noted previously.[7]

When dietary protein intake is insufficient, the body responds by decreasing protein turnover, and mobilizing protein from LBM to support essential protein synthesis.[1-4] In addition to the effect of inadequate protein intake, aging itself has a detrimental effect on protein turnover and LBM.[9] In one review, 85% of the studies found an age-related decline in endogenous protein synthesis.[43] In otherwise healthy

animals, even mild protein deficiency can significantly impair immune function.[8,44] These effects may be more pronounced in the older dog due to reduced LBM and age-related reduction in protein turnover.

Inadequate protein intake increases the rate of loss of LBM in aging dogs, while abundant protein reduces the loss.[9] There is growing recognition of the importance of this change in body composition. Loss of LBM has recently been recognized as a predictor of morbidity and mortality in aging subjects, including dogs.[3,11-14]

In addition, calorie intake affects dietary protein need. Older dogs tend to consume fewer calories, thus less food, than younger dogs.[45,46] With lower calorie intake, the percent of calories from protein must increase to maintain the same protein intake. Therefore, diets for older dogs must contain a higher percentage of dietary protein, or increased protein to calorie ratio, to maintain their protein intake. Diets containing at least 25% of calories from protein (approximately 7 g protein/100 Kcal diet) should meet the protein needs of most healthy senior dogs.

Summary and Conclusions

Based on a comprehensive review, there remains no evidence that dietary protein causes kidney damage, or any other adverse effects, in healthy dogs. Even in dogs with chronic kidney disease, dietary protein does not appear to contribute to kidney damage. However, in chronic kidney disease, there can be an accumulation of byproducts of protein metabolism, which may contribute to uremic signs. Hence, in these patients, dietary protein restriction may be of benefit. On the other hand, dietary protein is important to support normal protein turnover and maintain lean body mass. Healthy, aging dogs have an increased requirement for dietary protein. When insufficient protein is provided, it can aggravate the age-associated loss of lean body mass and may contribute to earlier mortality. Unless medically indicated, intake of dietary protein should not be restricted.

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