Amino acid nutrition: A vital foundation for canine and feline health

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Elizabeth Morris, Ph.D. and Julia Guazzalli Pezzali, DVM, MS, Ph.D., emphasize that amino acid nutrition is a crucial foundation for the health of both dogs and cats

Complete and balanced pet food must be formulated to meet all the nutritional needs of the intended animal population at a specific physiological state, enabling these products to serve as the sole source of nutrition. Certain nutrients must be included in the diet at minimum levels to classify a product as “complete”. These nutrients, known as dietary indispensable nutrients, are defined as those that cannot be synthesized endogenously in sufficient quantities to support specific biological functions of the individual (Chipponi et al., 1982). Among the more than forty dietary indispensable nutrients required by healthy dogs and cats, ten are proteogenic amino acids (AA). Chemically, most amino acids are defined as organic molecules composed of by a central carbon atom bonded to a hydrogen atom (-H), an amino group (-NH2), a carboxyl group (-COOH), and a distinctive side chain that differentiates each AA. The capacity of an animal to synthesize the side chain initially determines whether the AA is classified as either dietary indispensable or dispensable.

Amino acids capable of forming peptide bonds with one another serve as building blocks for larger macromolecules known as proteins. Most notably, proteins are essential for the formation of muscle tissue, which is critical for movement, support, and metabolic homeostasis. However, proteins encompass a wide variety of biomolecules, including enzymes and hormones, which regulate key physiological processes (Wu et al., 2014). Protein synthesis becomes restricted when a deficient indispensable AA limits the translation process at the tRNA level, impacting many metabolic functions (Pavlova et al., 2020). For instance, deficiencies in phenylalanine and tyrosine are well-documented to impair black hair pigmentation in cats, as tyrosine serves as the precursor to melanin, the pigment responsible for black coloration (Yu et al., 2001; Anderson et al., 2002; Morris et al., 2002). Tryptophan, another indispensable AA, is the precursor to the neurotransmitter serotonin, resulting in a possible impact of dietary tryptophan intake on behavioral modulation in dogs (Bosch et al., 2007). However, adequate AA provision is not solely about meeting minimum recommendations; dietary balance among AA also plays a critical role. For example, the absorption of tryptophan is influenced by its concentration relative to that of large neutral AA (Broer, 2008). Thus, even if all AA are supplied at or above the minimum recommended levels, they may not necessarily be balanced to optimize a targeted outcome.

The physiological requirement for an AA is defined as the minimum amount in its bioavailable form needed to support a specific biological function. Empirical determination of AA requirement relies on detecting changes in a metabolic parameter in response to graded intake of the test AA. Ideally, a minimum of seven diets with varying AA concentrations (intake) should be carefully formulated and fed to a group of animals, representing the target population, in a crossover design to accurately establish the minimum AA requirement (breakpoint estimate) (Pencharz and Ball, 2003). Growth rate in kittens and puppies, and nitrogen balance in mature animals are classic biological responses that have been utilized in the past to empirically determine AA requirement in dogs and cats (NRC, 2006). It is important to note that AA requirements are not static and can be influenced by both intrinsic and extrinsic factors. Intrinsic factors such as age, sex, breed and health status may alter AA needs. In some cases, dispensable AA may also become conditionally indispensable, meaning they must be provided in the diet due to an increased metabolic demand (Reeds, 2000).

Our current knowledge of AA requirements in dogs and cats is still limited as empirical studies that determine AA physiological requirements are scarce. In adult cats, there are no empirical determinations for most indispensable AA (NRC, 2006), with current recommendations being a result of extrapolation from studies on growing kittens. Furthermore, traditional techniques, such as nitrogen balance, tend to underestimate the true AA requirements in mature animals (Zello et al., 1995), further challenging the accuracy of current recommendations. Recent studies using more sensitive and modern techniques have identified greater AA recommendations than those proposed by the NRC for adult dogs (Templeman et al., 2019; Mansilla et al., 2020; Sutherland et al., 2020) and cats (Pezzali et al., 2024; Lambie et al., 2024), underscoring the urgency for more foundational research.

Differences in AA requirements among dog breeds have also been reported in the aforementioned studies, demonstrating how personalized nutrition may offer health benefits for individuals or more targeted populations of dogs and cats. Extrinsic factors can also impact AA requirements. For example, high-fiber diets may reduce the digestibility of AA (Zhang et al., 2024), potentially increasing the amounts needed in the diet. Heat application during food processing can lead to the oxidation of certain AA or their reaction with other molecules in the food matrix, making them metabolically unavailable (Johnson et al., 1998). Any factor that lowers the digestibility or bioavailability of AA results in an increase in the dietary supply required to meet the animal's metabolic demand.

Accurate dietary AA recommendations in commercial pet foods pose significant challenges. Developing these recommendations requires comprehensive knowledge of the minimum physiological requirements of animals at specific physiological states, an in-depth understanding of dietary factors influencing the digestibility and bioavailability of AA, and an awareness of how genetic and environmental factors affect AA needs. The hundreds of ingredients used in pet food products, significant nutrient variability in animal-based ingredients, diverse processing technologies used to produce intact ingredients

and complete diets, and the complex matrix of pet food also contribute to the challenge of providing accurate AA recommendations. A thorough understanding of how different processing conditions affect AA bioavailability in different ingredients and pet food matrices is essential to move towards more accurate nutritional recommendations.

While providing dietary indispensable AA in excess might temporarily address these challenges and guarantee, most of the time, the minimum AA intake for all individuals, it may not be the ideal solution for optimizing animal health and supporting sustainable pet food production. A deeper understanding of how various processing techniques influence AA bioavailability, along with foundational knowledge of AA requirements of dogs and cats under different physiological states, environmental conditions and genetic/ breed considerations, are essential to move towards precise nutrition in the pet food industry. However, this is by no means an easy task and will require collaborative efforts to generate extensive data that can enhance our understanding of AA nutrition in dogs and cats.

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