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Original Scientific Paper

Amino acid profiling of commercial dog and cat foods: comparative analysis and principal component evaluation

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A R T I C L E I N F O

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A B S T R A C T

This study evaluated the amino acid composition of commercial dog and cat foods and examined differences between them. Fifteen samples were analyzed using ion-exchange chromatography, followed by principal component analysis (PCA). Cat food contained higher levels of most amino acids, especially taurine, and had greater total amino acid (protein) content than dog food. PCA showed clear separation between the two groups, driven mainly by taurine and overall amino acid concentration. Glycine, histidine, and methionine contributed modestly to group differentiation. Dog food samples had more uniform amino acid profiles, while cat food samples showed greater variability, particularly in glycine, glutamic acid, leucine, and alanine content. These findings reflect species-specific nutritional requirements and indicate that cat foods, due to stricter amino acid demands, show higher variability between formulations, while dog foods are formulated in a more uniform way. Further research with a larger and more diverse sample set is needed to confirm these results and assess broader formulation trends in the pet food industry.

1. Introduction

Amino acids are essential nutrients that play a fundamental role in the growth, maintenance, metabolism, and overall health of pets. As the building blocks of proteins, amino acids play a crucial role in enzyme activity, immune system function, and energy metabolism. Dogs (*Canis familiaris*) and cats (*Felis catus*), although both classified within the order *Carnivora*, differ significantly in their physiological requirements for amino acids due to their distinct evolutionary paths, digestive capacities, and metabolic adaptations (*Li & Wu*, 2023).

Although anatomically classified as carnivores, dogs exhibit several metabolic characteristics of omnivores. They are capable of synthesizing certain nutrients endogenously, such as converting β-carotene into vitamin A, tryptophan into niacin, cysteine into taurine, and linoleic acid into arachidonic acid (*NRC*, 2006). This metabolic adaptability enables dogs to tolerate a broader range of dietary ingredients, including plant-based sources, and to thrive on well-balanced vegetarian diets when appropriately supplemented with nutrients that are otherwise absent or insufficient in plant materials (*Oberbauer & Larsen*, 2021). In contrast, cats are

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obligate carnivores with limited ability to regulate amino acid catabolism and maintain consistently high activity of nitrogen-degrading enzymes, regardless of protein intake (*Che et al.*, 2021). As a result, their protein requirements are high and cannot be met through plant-based diets. Furthermore, cats are particularly sensitive to deficiencies in certain amino acids, especially arginine, where even a single deficient meal can cause life-threatening hyperammonaemia, and taurine, which they cannot synthesize in sufficient amounts and must obtain directly from animal tissues (*Legrand-Defretin*, 1994).

To ensure dietary adequacy, organizations such as the National Research Council (NCR), the European Pet Food Industry Federation (FEDIAF) and the Association of American Feed Control Officials (AAFCO) have published species-specific nutritional recommendations. These guidelines define minimum and maximum levels of essential amino acids in pet food, adapted to life stage and physiological state. Notably, most essential amino acids are required in higher amounts in cat food compared to dog food, reflecting the cat's obligate carnivorous nature and its reduced biosynthetic capacity for several key compounds.

In both Serbia and the European Union, the use of amino acids in pet food is regulated as part of the broader framework governing nutritional additives. While their inclusion is permitted, neither system sets specific minimum or maximum levels for amino acids in finished products. In Serbia, the Rulebook on the Quality of Animal Feed (*Official Gazzete*, 2017) defines general quality standards but leaves the formulation of amino acid content to manufacturers, based on the nutritional requirements of the target species. Similarly, in the EU, Regulation (EC) No 1831/2003 (*European Union*, 2003) authorizes the use of amino acids as feed additives, with recommended levels guided by non-binding industry standards, such as those developed by FEDIAF or other organizations.

Since no regulation at the national, European, or international level defines the total amino acid content required in finished pet food, manufacturers are responsible for formulating products in accordance with recommended nutrient profiles and may supplement specific amino acids as additives to optimize the overall amino acid composition.

Given the wide range of formulations on the pet food market and the growing use of alternative ingredients, the amino acid profile of commercial diets may vary significantly. This study aimed to analyze and compare the amino acid composition of selected dog and cat foods, using principal component analysis (PCA) to explore whether systematic differences exist between formulations intended for each species, and how these differences align with established nutritional expectations.

2. Materials and methods

2.1. Sample collection

A total of 15 pet food samples, 7 dog foods (DF1-7) and 8 cat foods (CF1-8), were collected and analyzed during 2025. All samples were submitted by regular clients of the Institute of Meat Hygiene and Technology in Belgrade, with the objective of the full amino acid profiling of their products. Analyses were conducted at the Laboratory for Instrumental Chemistry within the Institute. The products represented various manufacturers and formulations and were analyzed as received, without further processing. Each sample was stored in its original packaging under ambient conditions until laboratory analysis.

2.2. Determination of amino acid composition

Amino acid content in the pet food samples was quantified using a Biochrom 30+ amino acid analyzer (Biochrom, Cambridge, UK), based on the ion-exchange chromatography method outlined in the standard method (*ISO*, 2005). The analytical process relied on strong cation-exchange chromatography coupled with post-column derivatization using ninhydrin, enabling accurate detection of amino acids. Absorbance was measured at 570 nm, except in the case of proline, which was detected at 440 nm due to its unique properties. Prior to chromatographic separation, samples were hydrolyzed in 6M hydrochloric acid (Merck, Germany) at 110 °C for a duration of 24 hours. After hydrolysis, the solutions were cooled to ambient temperature (20 °C), diluted to a final volume of 200 mL with a pH 2.2 buffer (Biochrom, Cambridge, UK), and filtered through a 0.22 μm PTFE membrane. The resulting filtrates were refrigerated until analysis. Individual amino acids were identified by matching their retention times with those in a reference standard mixture containing 21 amino acids (Sigma-Aldrich, St. Louis, MI, USA), and concentrations were determined using norleucine as the internal standard.

2.3. Statistical analysis

Statistical processing was performed using JMP® 11 software (SAS Institute Inc., Cary, NC, USA). Principal component analysis (PCA) was applied to explore patterns and differences in the amino acid composition of pet food samples. The data set included quantified values for all detected amino acids, and PCA was conducted using standardized variables to allow for meaningful comparison across samples.

3. Results and discussion

The amino acid composition of 15 commercial pet food samples was determined and is presented in Table 1, which shows the individual amino acid concentrations and total amino acid content (ΣAA) expressed in g/100 g of product. Cat food samples generally exhibited higher levels of most amino acids compared to dog food samples, particularly for taurine, arginine, lysine, and leucine. This difference is consistent with established nutritional knowledge and previous reports, as domestic cats have inherently higher dietary requirements for protein and several essential amino acids than dogs, due to their limited ability to down-regulate amino acid catabolism and to synthesize certain amino acids, such as taurine and arginine (*NRC*, 2006, *Kanakubo et al*., 2015).

To further explore differences in amino acid profiles between the two product types, principal component analysis (PCA) was applied. The PCA results are shown in Figure 1, with the first two principal components accounting for 94.82% of the total variance (PC1 = 90.7%, PC2 = 4.12%). The PCA plot revealed a clear separation between cat and dog food samples along the PC1 axis, suggesting that systematic differences exist in their amino acid profiles.

Among the individual amino acids, taurine was identified as the most discriminating variable, with markedly higher values in cat food. This finding is in line with the obligate carnivorous nature of cats and their dietary dependence on preformed taurine. In addition, glycine, histidine, and to a lesser extent

Table 1. Amino acid composition and total amino acid content (g/100 g sample) of analyzed pet food products.

	CF1	CF2	CF3	CF4	CF5	CF6	CF7	CF8	DF1	DF2	DF3	DF4	DF5	DF6	DF7
Ala	2.04	3.53	2.88	2.12	3.08	3.76	2.79	2.00	2.19	1.44	1.47	1.90	1.36	1.87	1.08
Arg	2.28	3.74	2.81	2.10	3.04	3.80	2.77	2.13	2.14	1.44	1.48	2.21	1.35	2.05	1.02
Asp	2.82	4.67	3.58	2.63	3.77	4.48	3.75	2.85	2.73	1.84	1.77	2.74	1.71	2.78	1.3
Cys	0.32	0.82	0.56	0.63	0.67	0.71	0.48	0.36	0.45	0.45	0.42	0.32	0.18	0.34	0.24
Phe	1.32	2.22	1.65	1.4	1.81	2.13	1.61	1.27	1.29	1.04	1.02	1.29	0.87	1.28	0.71
Gly	3.08	5.29	4.53	3.02	4.83	6.55	3.83	2.95	3.17	1.86	2.05	2.90	1.78	2.15	1.46
Glu	4.66	7.75	5.89	5.23	6.30	7.54	5.86	4.84	4.55	4.12	3.89	4.41	3.65	4.44	2.77
His	0.84	1.22	0.69	0.59	1.07	1.37	0.87	0.68	0.76	0.57	0.58	0.80	0.40	0.60	0.36
Ile	1.05	1.85	1.33	1.24	1.55	1.63	1.46	1.05	1.07	0.83	0.81	0.93	0.70	1.16	0.54
Leu	2.20	3.80	2.83	2.39	3.12	3.62	3.14	2.11	2.20	1.81	1.84	2.16	1.54	2.20	1.28
Lys	2.07	3.60	2.70	2.00	2.86	3.30	3.14	2.17	2.09	1.26	1.14	1.86	1.17	2.26	0.9
Met	1.10	1.55	1.24	1.13	1.30	1.61	1.54	1.24	0.98	0.65	0.74	0.88	0.42	1.04	0.59
Pro	1.61	2.53	2.85	2.39	3.12	3.02	2.34	1.26	2.33	1.54	1.11	1.27	1.32	1.54	1.00
Ser	1.45	2.49	1.92	1.55	2.03	2.49	1.94	1.50	1.46	1.22	1.16	1.48	1.02	1.33	0.81
Tau	0.40	0.90	0.61	0.69	0.58	0.24	0.79	0.70	0.33	0.32	0.22	0.28	0.29	0.39	0.21
Tyr	0.95	1.59	1.15	0.95	1.25	1.44	1.11	0.84	0.88	0.75	0.74	0.89	0.54	0.83	0.45
Thr	1.26	2.18	1.61	1.28	1.72	2.03	1.66	1.27	1.23	0.91	0.88	1.22	0.81	1.21	0.63
Trp	0.40	0.66	0.41	0.30	0.50	0.54	0.49	0.37	0.38	0.27	0.27	0.37	0.25	0.35	0.28
Val	1.28	2.33	1.77	1.60	2.04	2.19	1.81	1.27	1.43	1.06	1.07	1.16	0.91	1.42	0.71
ΣAA	31.14	54.31	41.03	33.27	44.67	52.46	41.4	30.87	31.69	23.41	22.67	29.08	20.28	29.26	16.35

CF – cat food; DF – dog food.

methionine, contributed modestly to group separation. However, no single amino acid, aside from taurine, was sufficient to account for the divergence between the two groups. Rather, the dominant factor driving the separation was the total amino acid content, which closely reflects the overall protein level in the product. These results emphasize that while certain amino acids, like taurine, are species-specific dietary requirements, the broader distinction between dog and cat foods lies in their cumulative amino acid concentrations. PCA thus proved to be an effective analytical tool for identifying these formulation patterns and nutritional strategies tailored to species-specific needs.

In addition to group separation, PCA results also revealed differences in the degree of data dispersion between the two product types. Dog food samples displayed a more uniform amino acid composition, clustering more tightly in the PCA plot and showing smaller variability across most individual amino acids. In contrast, cat food samples were more dispersed, indicating greater formulation variability. Quantitatively, the total amino acid content (ΣAA) in cat food varied from 30.87 to 54.31 g/100 g, with a range of 23.44 g/100 g, whereas in dog food, it ranged from 16.35 to 31.69 g/100 g, yielding a smaller range of 15.34 g/100 g. Among individual amino acids, glycine, glutamic acid, leucine, and alanine showed notably higher variation in cat food samples. For instance, glycine ranged from 3.02 to 6.62 g/100 g in cat food (range: 3.60 g/100 g), compared to 1.44 to 3.15 g/100 g in dog food (range: 1.71 g/100 g). Similar patterns were observed for glutamic acid (range: 3.09 g/100 g vs. 1.78 g/100 g in cat and dog food, respectively), leucine (1.69 g/100 g vs. 0.92 g/100 g in cat and dog food, respectively), and alanine (1.76 g/100 g vs. 1.11 g/100 g in cat and dog food, respectively). The observed ranges of amino acid concentrations, as well as the ratios between cat and dog food samples, are consistent with the results of previous studies conducted in other countries (*Leiva et al.*, 2019, *Choi et al.*, 2024).

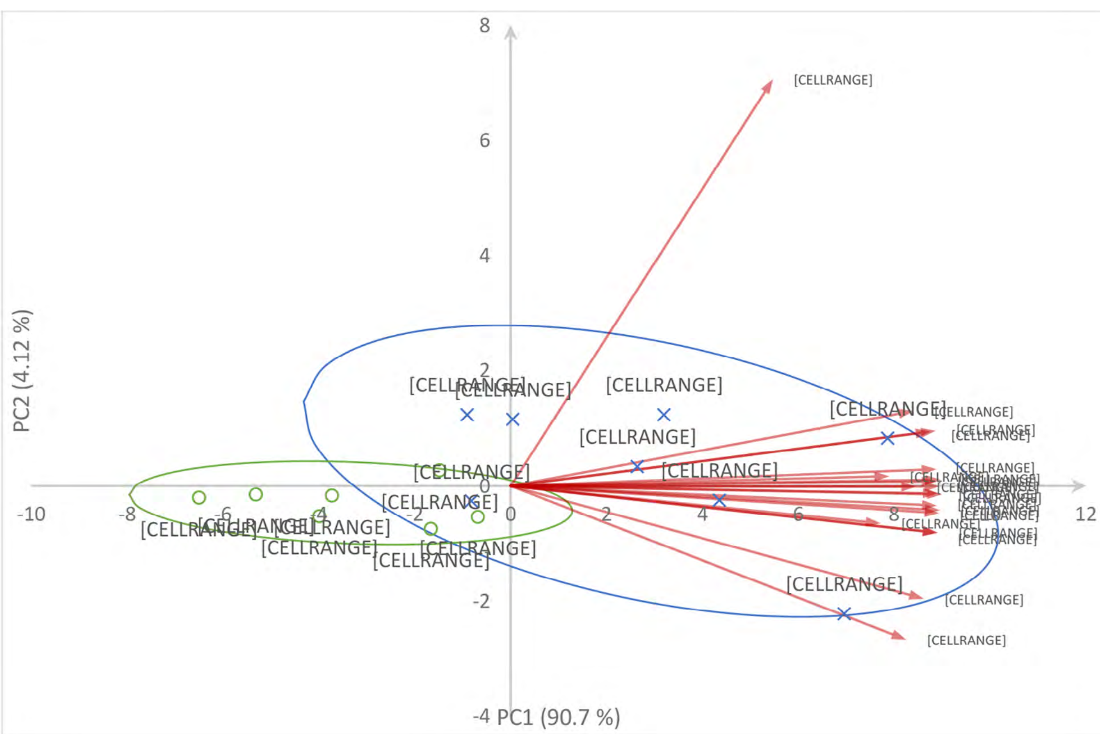

Figure 1. Principal component analysis (PCA) of amino acid composition in dog and cat food samples.

4. Conclusion

This study demonstrated clear differences in the amino acid composition of commercial dog and cat foods. Cat food samples contained higher levels of most amino acids, particularly taurine, and had significantly greater total amino acid (protein) content. PCA analysis confirmed a distinct separation between the two product types, driven primarily by taurine and cumulative amino acid levels.

Dog food formulations were generally more uniform, which may reflect a consistent industry approach to meeting the nutritional needs of omnivorous species, whereas cat foods, designed to satisfy stricter amino acid requirements, showed greater variability between formulations. In contrast, the greater variability observed in cat food may reflect manufacturer-specific strategies to meet the stricter amino acid requirements of obligate carnivores. This reinforces the conclusion that, aside from taurine, the most defining feature of feline food formulations is their consistently higher and more variable total amino acid content.

Further research involving a larger and more diverse sample set is needed to confirm these findings and to better understand formulation trends and nutritional consistency across the pet food industry.

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