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Enhancing Pet Nutrition Research and Practice: A Systematic Review of Evidence Gaps and Clinical Applications

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Abstract: This systematic review synthesizes evidence from 10 studies published between 2005 and 2025, focusing on nutritional interventions, functional ingredients, and their resulting health outcomes in dogs and cats. The scope of the review covers research into cognitive function enhancement, osteoarthritis management, palatability assessment, periodontal disease prevention, aging interventions, plant extracts, nutrigenomics, microbiome modulation, and metabolomics. The studies included systematic reviews (n=8) and primary research examining enriched diets, nutraceuticals, and functional ingredients across various health domains. The evidence demonstrates beneficial effects for omega-3 fatty acids in improving cognitive function and managing osteoarthritis, with effect sizes (Cohen's d) ranging from d=0.58 to d=1.19. However, significant methodological heterogeneity is apparent, characterized by median sample sizes of only 11.5 animals per group and widely varying intervention durations, from 28 days to 3 years.

➢ ***Key Research Gaps Identified:***

- **Insufficient long-term safety data for most interventions, compounded by limited regulatory oversight in the supplement market. [1]**
- **Lack of standardized outcome measures and validated biomarkers, particularly in fields like osteoarthritis management, where there is no current consensus on the most useful endpoints. [2]**
- **Limited species-specific research, particularly for cats, presenting a critical taxonomic bias.**
- **Poor integration of physiological and behavioral measures, especially in palatability research.**
- **Minimal translation of biological findings into practical clinical protocols.**

The review highlights opportunities for developing validated biomarkers, standardized protocols, and evidence-based clinical pathways while addressing existing geographic, taxonomic, and methodological biases in the current research landscape.

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I. INTRODUCTION

Advances in veterinary medicine and the rising societal role of pets have led to significantly extended lifespans for dogs and cats. This longevity, however, introduces new challenges in managing prevalent age-related conditions, such as cognitive dysfunction syndrome (CDS), osteoarthritis, and periodontal disease. Furthermore, a large proportion of the companion animal population is overweight or obese (approximately 55% of dogs and 53% of cats in the U.S.). Evidence-based nutritional strategies are therefore essential for optimizing the healthspan of companion animals.

Nutritional science offers critical modalities for preventing and managing chronic diseases:

- Plant Extracts: Compounds like polyphenols and enzymes are increasingly used for their antioxidant, anti-inflammatory, and antimicrobial properties. [3]
- Microbiome Modulation: The gastrointestinal microbiome is a metabolically active organ linked to health, and its composition can be influenced by diet to affect conditions from GI disease to obesity and kidney disease. [4]
- Palatability: This remains a major determinant of pet food performance, directly impacting voluntary intake and therapeutic success. [5]

Despite a proliferation of functional foods and nutraceuticals in the market, the evidence supporting their efficacy is highly variable. The lack of standardized oversight

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further complicates consumer confidence and clinical recommendation [1]. This systematic review aims to address critical research gaps by synthesizing current evidence, evaluating methodological quality, and providing recommendations to advance the field toward standardized, evidence-based clinical practice.

II. CHARACTERISTICS OF INCLUDED STUDIES AND INTERVENTIONS

The review includes 10 studies published over two decades (2005–2025), predominantly systematic reviews (n=8). A significant limitation is that full text was available for only three studies, restricting detailed methodological assessment for the remaining seven, which were available only as abstracts.

➢ *Methodological Challenges and Biases*

- Taxonomic Bias: Research heavily favors dogs, with substantially fewer studies including cats. For example, in the 30 cognitive function trials reviewed, only 2 examined cats, and only 3 of the 72 osteoarthritis trials focused on felines. This is problematic given known species-specific differences in metabolism and disease manifestation.
- Sample Size: Median sample sizes were small (11.5 dogs per test group), and only three trials reported power calculations, raising concerns about statistical rigor and generalizability.
- Duration: Intervention durations varied widely from 28 days to 3 years, but the median duration was only 91 days. This short-term follow-up raises questions about long-term efficacy and safety, a critical missing piece in the current literature [1].

➢ *Nutritional Interventions Examined*

Omega-3 fatty acids were the most extensively studied intervention, evaluated for both cognitive function and osteoarthritis management. Key interventions included:

- Omega-3 Fatty Acids (EPA and DHA): Delivered as enriched diets or supplements (e.g., 7–94.5 mg/kg).
- Antioxidants (Vitamins E and C): Included in enriched diets (e.g., Vitamin E: 1.2–19 mg/kg).
- Medium-chain triglycerides (MCTs): Used in enriched diets (e.g., 5.5%).
- Prebiotics (FOS, inulin): Investigated for their microbiome-modulating effects.
- Joint Supplements: Chondroitin-glucosamine and collagen-based products.

The majority of interventions were delivered as enriched diets or supplements. A major limitation was the absence of detailed dosing protocols for many interventions, which hinders clinical translation.

III. EFFECTS ON HEALTH OUTCOMES

A. Cognitive Function

Omega-3 fatty acids, particularly at higher doses, showed cognitive benefits, specifically improving learning and executive functions. [6]

- Beneficial effects were observed with DHA at 26 mg/kg or a combined DHA/EPA dose of 67.5/27 mg/kg, respectively.
- Medium-chain triglycerides (MCTs) at 5.5% dietary inclusion improved executive and visuospatial functions in dogs.
- S-adenosyl methionine improved executive functions in both cats and dogs. [7]
- Antioxidants alone were less effective but are critical for stabilizing omega-3 fatty acids. [8]
- Study Quality: Studies on enriched diets demonstrated statistically significantly higher methodological quality than supplement studies ($p=0.035$).

B. Osteoarthritis and Pain Management

Meta-analysis findings demonstrated the clear clinical analgesic efficacy of omega-3 interventions [9].

- Omega-3 Supplements: Showed a large beneficial effect with an effect size of $d=1.19$ ($p<0.001$).
- Omega-3-Enriched Diets: Showed a medium to large beneficial effect with an effect size of $d=0.58$($p<0.001$).

➢ *Ineffective Interventions:*

- Chondroitin-glucosamine: Demonstrated a marked non-effect ($d=-1.39$, $p<0.001$). The authors recommended that these products should no longer be used for pain management in canine and feline osteoarthritis [9].
- Collagen-based products: Exhibited weak efficacy with a negative effect size ($d=-1.57$, $p<0.001$) [9]
- Pain Assessment: Objective pain quantification methods (e.g., kinetic or actimetric assessment) are considered more valid and reliable than subjective reports by owners or veterinarians. The use of validated owner-completed questionnaires, such as the Canine Brief Pain Inventory (CBPI), has also proven essential for capturing spontaneous chronic pain in the home environment and is now often required for regulatory approval [5].

C. Microbiome and Metabolome Effects

Dietary components significantly impact the GI microbiome, influencing conditions like gastrointestinal disease, obesity, and kidney disease . [8]

- Dietary Shifts: Microbiome composition changes rapidly in response to diet.[12] The addition of fiber, for example, leads to significant changes in operational taxonomic units and increases beneficial Short-Chain Fatty Acids (SCFAs). [4]
- Clinical Relevance: Hydrolyzed protein diets induce rapid remission in dogs with chronic enteropathy. [10] Diets

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formulated for kidney disease can manage uremia symptoms in cats, potentially extending lifespan.

- Research Gap: Current research is heavily focused on characterizing the microbiome composition (taxonomy) rather than its functional capabilities (e.g., postbiotic production), limiting mechanistic insight. The understanding of the gut metabolome and its markers remains emergent.

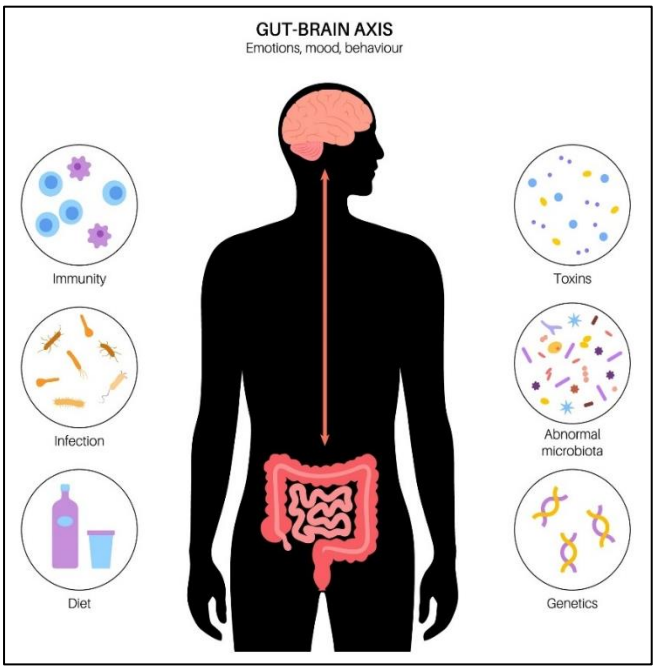

Fig 1 Gut-Brain Axis

D. Palatability and Acceptance

Palatability directly impacts voluntary intake and therapeutic success [4].

➢ *Species-Specific Preferences are Critical for Compliance:*

- Dogs: Tolerate solid oral dosage forms well but poorly tolerate liquid formulations.
- Cats: Poorly tolerate solid oral forms but readily accept pastes and liquid formulations.
- General Preference: Meat-based flavors yield high palatability across species.

Research has identified over 15 innovations in delivery systems [4], but their impact on actual nutrient utilization and long-term health benefits remains largely unexplored. The integration of sensory evaluation with physiological and health outcomes remains a critical gap.

IV. CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH

The evidence base for companion animal nutritional interventions is growing but is highly heterogeneous. Strong evidence supports the use of omega-3 fatty acids for cognitive function and osteoarthritis. [7] However, the methodological limitations and research gaps are substantial.

➢ *Methodological Recommendations*

To achieve comprehensive, evidence-based nutritional care pathways, future research must prioritize:

- Rigor and Power: Conduct multi-center, long-term clinical trials with adequate sample size determination via power calculations (the median of 11.5 animals per group is insufficient).
- Standardization: Develop and validate standardized assessment tools and biomarkers across all health domains (aging, microbiome, dental health) to enable meaningful cross-study comparison. The current landscape of canine osteoarthritis outcome measures, for example, is highly fragmented and non-standardized. [1]
- Long-Term Efficacy and Safety: Implement long-term follow-up (minimum 6–12 months for chronic conditions, 2–5 years for aging) with systematic and comprehensive adverse event reporting. The absence of long-term safety data is a major concern given the unregulated nature of many veterinary supplements. [1]
- Species-Specific Focus: Prioritize feline-specific research to address the current 13.5-fold disparity in cognitive studies and 23-fold disparity in osteoarthritis trials.
- Integration: Encourage multi-outcome studies that simultaneously evaluate interconnected systems (e.g., omega-3 studies assessing cognitive function, joint health, inflammatory markers, and microbiome composition). Palatability research must integrate bioavailability and health outcome measures.

➢ *Clinical Translation*

Translating research into practical guidelines requires:

- Clear Dosing Protocols: Establish optimal dosing for key interventions like omega-3 fatty acids for different breeds, severity levels, and concurrent conditions.
- Training and Tools: Invest in standardized veterinary nutrition education, communication tools for practitioners, and intervention programs to facilitate clinical implementation capacity.
- Evidence-Based Pathways: Systematically translate research into evidence-based clinical guidelines, utilizing validated tools like the Canine Brief Pain Inventory (Brown et al., 2018) and incorporating recommendations against ineffective treatments, such as the use of chondroitin-glucosamine for osteoarthritis pain [9] .

Nutritional interventions offer substantial promise for improving the health and quality of life for companion animals as their lifespans increase. Realizing this potential depends on a commitment to methodological rigor and translational research that effectively bridges the gap between biological understanding and clinical application.

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