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JIVT: An Introduction

The Journal of Integrative Veterinary Therapies (JIVT) is published twice a year by the College of Integrative Veterinary Therapies (CIVT). It contains papers on all aspects of integrative veterinary medicine, including Chinese and Western herbal medicine, acupuncture, rehabilitation, natural nutrition, environmental medicine, philosophy, history, clinical cases and commentary.

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ARTICLE

Nutrition Across the Aging Spectrum: Supporting Senior and Geriatric Dogs and Cats

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Introduction

Nutrition is fundamental at every stage of life, from growth through maturity and into advanced age. As pets enter their senior and geriatric years, feeding practices require a shift in focus to address age-related physiologic changes and emerging health challenges, with the goal of preserving vitality, function and quality of life (QoL), or "healthspan." Geriatric pet care is becoming increasingly important for veterinary healthcare teams (VHCT) and pet owners alike as longevity in companion animals rises. Senior pets are now estimated to represent more than one-third of the U.S. pet population, a proportion that continues to grow (AVMA 2024). Many owners perceive that older pets have different nutritional needs, which is both a result of, and a cause for the pet food market to have an overabundance of diets promoting benefits directed at seniors such as improved mobility, digestion, immune function, and cognition. However, there is still no recognized AAFCO nutrient profile defining "senior" life stage nutritional requirements (AAFCO 2025). This absence contributes to a significant disconnect between owners' and VHCT' assumptions about the nutritional features of senior diets and their actual composition (Summers 2020). Nutrient profiles vary widely between 'senior' products, reflecting manufacturer philosophies rather than standardized guidelines. As a result, feeding a product marketed for aging pets does not necessarily ensure it meets the needs of the individual animal.

Defining "Senior" vs. "Geriatric" Life Stages

In veterinary medicine, the terms *senior* and *geriatric* remain inconsistently defined, and may be used interchangeably. Application of these terms also differ between canine and feline patients. The 2021 AAHA/AAFP Feline Life Stage Guidelines classify cats over ten years of age as seniors and those more than fifteen years old as "super seniors" or geriatric (Quimby et al. 2021; Ray et al. 2021). In dogs, lifespans and aging changes vary widely by breed and body size, so the 2019 AAHA Canine Life Stage Guidelines define senior dogs as those in the final 25% of their estimated lifespan, with geriatric dogs being those at or beyond their expected lifespan through the end of life (Creevy et al. 2019). Chronologic age groupings are therefore arbitrary, and the point at which an individual pet reaches advanced "biologic age" is highly variable. A more clinically relevant focus for VHCTs is the progressive physiologic and functional decline that characterizes advanced aging. McKenzie et al. (2022) have proposed the framework of *Canine Geriatric Syndrome* (CGS), which encompasses multiple interrelated physical, functional, behavioral, and metabolic changes with resulting clinical manifestations such as frailty, diminished quality of life, and age-associated disease. This conceptual model, though developed for dogs, could also apply to cats. For the purpose of this discussion, senior cats are those over ten years of age and dogs in the final 25% of their expected lifespan. Geriatric refers to advanced-aging senior pets at or beyond their life expectancy and exhibit a constellation of physical and functional changes that predispose them to age-related dysfunction, disease and mortality. Although defining the onset of geriatric life is challenging and aging is inevitable, proactive preventive care and nutritional management throughout life can help delay physiologic decline, reduce morbidity and mortality, and improve quality of life (Churchill 2021; Freeman 2018; Saker 2021; Laflamme & Gunn-Moore 2014; Bermingham 2024; Kealy 2002).

Nutritional Assessment, Monitoring and Adjustment

Before considering diet recommendations, a thorough nutritional evaluation should be performed. The goal of the assessment is to gather the necessary information to provide a patient-specific nutrition plan. A complete assessment is an iterative process including the evaluation of the patient (signalment, medical history, physical examination and appropriate diagnostic testing), the diet (all foods, treats, supplements and methods of feeding) and the human and environmental factors that influence intake (Baldwin 2010; WSAVA 2011; Cline 2021). This process is dynamic, requiring repeated evaluations over time as the pet ages and circumstances change.

Older pets require an extended nutritional evaluation that goes beyond basic screening, particularly when multiple nutritional risk factors are identified. This assessment should begin with careful observation of body and muscle condition, noting any changes in weight, body condition score (BCS) or muscle condition score (MCS). The diet itself must be evaluated to determine whether the pet is consuming ≥ 90% of an appropriate complete and balanced food. Appetite, feeding patterns and actual intake should be reviewed alongside the pet's ability to eat, including prehension, mastication and swallowing, especially in underweight patients. A thorough oral examination, addressing periodontal health, tonsils and other abnormalities can identify reasons for reduced intake. Senior pets may experience sensory changes such as olfaction, vision and food palatability; in some cases, palatability enhancers or warming the food may improve acceptance. Owner feeding practices should also be reviewed, including how medications or supplements are administered and whether treats, flavor enhancers or foods used for medication exceed the recommended 10% of daily caloric intake which can cause nutritional imbalances.

Mobility and access to resources must also be assessed. Clinicians should determine whether the pet can independently walk to and stand at food and water bowls or if competition from other pets or environmental barriers restricts intake. Screening for osteoarthritis, lameness or pain is essential, as these conditions can compromise comfort, mobility and feeding ability and interest.

Evaluation of cognitive function should address signs of disorientation, changes in recognition of familiar people or surroundings, altered interactions with family members, disrupted sleep–wake cycles, pacing, anxiety or inappropriate elimination without medical cause. Standardized tools such as DISHAA or VISHDAAL (Volk 2023) can help with a cognitive assessment. Finally, any changes in clinical status, including unintentional weight loss, shifts in BCS or MCS even in pets that appear ideal, or changes in energy, demeanor, urination or stool quality may signal underlying disease and should prompt further investigation. Unintentional weight loss frequently precedes disease diagnosis, especially in cats (Freeman 2016) and early detection may enable timely nutritional or medical intervention. Incorporating these domains into the nutritional assessment allows for earlier identification of age-related challenges and supports more precise, individualized dietary recommendations to optimize health and quality of life in geriatric pets.

Because of the wide variation in age-related metabolic changes and the heightened risk of progressive physiologic decline, the nutritional assessments in senior and geriatric pets should be regarded as a continuous, changing process. Care plans must be individualized and revisited frequently to accommodate the evolving needs of each patient. Clear communication with pet owners is essential to set expectations that nutritional management requires ongoing reassessment and adjustment, rather than relying on a fixed senior care protocol. Establishing a structured monitoring plan enables early recognition of emerging issues and provides timely opportunities to intervene or refine dietary strategies to support positive health outcomes. Collaboration with caregivers is central to maintaining adherence and ensuring adjustments can be made proactively to optimize health and quality of life (Churchill 2025).

Physiologic Changes of Age Impact Nutritional Needs

Aging is associated with functional decline, reduced resilience and increased vulnerability to chronic disease.

Energy Needs

Factors influencing daily energy needs are complex, particularly in senior and geriatric patients, where requirements may decrease, increase or remain stable. No single calculation for maintenance energy requirement (MER) accurately predicts the needs of an individual, underscoring the importance of continual monitoring and adjustment. Daily energy needs refer to the number of calories required to maintain energy balance, where caloric intake equals energy expenditure resulting in a stable healthy body weight.

Advancing age in dogs is generally associated with a decline in metabolic rate by 20–25% compared with young adults. In some cases, MER may fall below the calculated resting energy requirement (RER) (Stockman 2025; Keinzle 1991). Muscle mass, a primary determinant of energy needs, declines due to sarcopenia, the loss of lean mass associated with aging in the *absence* of the disease. Reduced activity, often secondary to common co-morbidities such as osteoarthritis or cognitive dysfunction, can further compound the loss of lean mass, and thus, energy needs. Cats in contrast, exhibit a steady decline in MER in middle age continuing through their senior years. By advanced senior and geriatric stages many cats demonstrate an *increase* in MER. This increased energy demand in geriatric cats may be partially explained by the fact that approximately one-third of them experience impaired digestion of fat and protein (Laflamme 2005).

Because of this variability in energy needs, monitoring body condition score (BCS), muscle condition score (MCS), and body weight trends is critical for detecting early changes and guiding diet adjustments. Subtle declines in body weight in seemingly healthy senior cats may precede overt clinical disease by years (Perez-Camargo 2004), highlighting the need for proactive diagnostics. Weight loss despite adequate or increased food intake should raise suspicion for conditions such as hyperthyroidism or gastrointestinal dysfunction, whereas weight gain on stable caloric intake may indicate decreased mobility from osteoarthritis, endocrine or cognitive disorders.

Body composition is one of the most important determinants of both health and lifespan. Excess body fat even without frank obesity has been linked to accelerated aging and reduced longevity across species (Kealy 2002; Cupp 2008). Adipose tissue also contributes to “inflammaging,” chronic low-grade inflammation that drives age-related diseases (Franceschi 2018). Conversely, evidence from a lifelong canine study demonstrated that caloric restriction to maintain lean body condition reduced disease incidence, delayed onset of illness and extended median lifespan by nearly two years (Kealy 2002). Obesity in both dogs and cats shortens life expectancy, impairs quality of life and contributes to multiple comorbidities including metabolic derangements, organ dysfunction and mobility impairments, while also imposing emotional and financial burdens on owners.

Therefore, achieving and maintaining an ideal body condition should be considered one of the most important health goals for aging pets. Frequent reassessment and timely adjustment of caloric intake and diet composition are essential to promote healthy aging and optimize healthspan.

Water Homeostasis

Dehydration is common in elderly humans, with a prevalence of 20–30%, primarily due to reduced thirst sensation and impaired renal concentrating ability. Dehydration is linked with frailty, morbidity and mortality (Lorenzo 2019), and even mild dehydration has been associated with impaired cognition, mood and pain perception (Churchill 2021). Although optimal water requirements for senior dogs and cats have not been established, close monitoring of hydration is essential. Pets with decreased mobility

may require environmental modifications such as multiple water bowls placed in accessible locations. Water intake should be encouraged during exercise or warm conditions, and pets with subclinical renal insufficiency are at particular risk. In cases where appetite is good but water intake is questionable, strategies such as feeding moist foods, adding water to meals or using nutrient-enriched water supplements can help maintain hydration.

Loss of Lean Body Mass: Sarcopenia and Cachexia

Sarcopenia is the progressive, generalized loss of skeletal muscle mass and function that occurs with aging in the absence of disease. Briefly, the rate of muscle injury and degradation exceeds the rate of repair and regeneration. **Cachexia**, in contrast, is a disease-associated syndrome characterized by loss of lean body mass with or without fat loss (Saker 2021). The pathogenesis of sarcopenia and cachexia are multifactorial and complex. Both sarcopenia and cachexia can independently have a negative impact on clinical outcomes. Cachexia and sarcopenia can also occur together, since chronic disease commonly impacts older pets. When they occur concurrently their effects can be synergistic, accelerating functional decline and further compromising quality of life. Approaches to mitigating muscle loss must be multimodal integrating nutritional modification combined with physical activity, as tolerated. Activity not only supports lean body mass but also contributes to mental stimulation and overall health.

Nutrient Priorities in Senior and Geriatric Pets

Protein

Dietary protein plays a critical role in maintaining lean body mass (LBM) in senior pets. Lean body mass influences strength and mobility and, in humans, has been linked to immune function, wound healing and improved survival. Although the precise protein requirements for senior pets remain unknown, healthy older animals do not benefit from protein restriction and function may decline when dietary protein is limited. Evidence indicates that aging dogs (Wannemacher 1966) and cats (Cupp 2008) benefit from higher protein intake, compared to young adults. Extrapolations from these studies and human data (Carbone 2019) suggest that senior pets may require up to 1.5–2 times maintenance intake, and should include muscle-building amino acids such as lysine and leucine (Saker 2021).

As a general guide, adult daily maintenance protein requirements should be considered the *minimum* for healthy seniors. According to the NRC (2006):

- Cats should receive at least 5 x $BW_{kg}^{0.67}$ grams of protein/day, with intake for healthy senior and geriatric cats increased to 7.5-10 x $BW_{kg}^{0.67}$ grams of protein/day.

- Dogs should receive at least 3.5 x $BW_{kg}^{0.75}$ grams of protein/day, with healthy senior and geriatric dogs requiring 5.25-7 up to x $BW_{kg}^{0.75}$ grams of protein/day.

These "senior" intake levels help minimize risk of deficiency and support preservation of LBM, with restriction warranted only when medically necessary. Because energy needs vary widely with age, protein intake must always be evaluated within the context of total caloric intake. Many senior pets require fewer calories by middle age, while those in advanced age may have reduced food intake or impaired nutrient digestion, particularly cats. Aligning energy and protein intake is therefore essential to maintain ideal body weight and minimize LBM loss.

Maintaining healthy body and muscle condition, alongside encouraging daily physical activity, enhances mobility, quality of life and healthspan. In general, diets for senior dogs should provide fewer calories but a higher proportion of protein or a greater protein-to-calorie ratio unless contraindicated by co-existing conditions. For healthy geriatric cats, diets often need to be high in protein, highly digestible, and calorie-dense to support weight maintenance. Regular reassessment of diet history, body weight and condition (BCS, MCS) is crucial.

Beneficial Fats

Omega-3 fatty acids: Increased intake of long-chain omega-3 polyunsaturated fatty acids (n-3 PUFA), provided through highly enriched diets or supplementation, offers several potential benefits for animals with cachexia or sarcopenia. Specifically, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) may help senior pets by modulating inflammation, thereby supporting muscle maintenance and reducing the progression of sarcopenia and cachexia. Although some interventional studies in aging humans have shown improvements in sarcopenia with omega-3 supplementation this has not yet been evaluated in senior dogs or cats (Freeman 2018). Omega-3 fatty acids have the strongest evidence of reducing synovial inflammation and pain from osteoarthritis (Barbeau-Grégoire 2022). EPA and DHA compete with arachidonic acid in cell membranes, producing fewer inflammatory leukotrienes, prostaglandins and thromboxanes, thereby helping reduce pain associated with osteoarthritis (OA). Marine-sourced oils (EPA > DHA) (Sierra 2008) are more effective than shorter-chain, plant-based n-3 oils. Clinical studies demonstrate improvements in lameness and mobility when dogs with OA receive dietary n-3 PUFA supplementation (Roush 2010). In cats with OA, diets containing 188 mg of omega-3 fatty acids per 100 kcal, or comparable supplementation, improved owner-reported activity (Lascelles 2010). Although no universally accepted dose exists, commonly cited recommendations for dogs with OA include combined EPA and DHA intake of 230–310 mg/kg of metabolic body weight, with lower doses of 90–110 mg/kg also effective (Bauer 2011). It is important to note that both wellness diets (particularly fish based) and therapeutic diets formulated to manage joint disease can contain high concentrations of omega-3 FAs. Any supplements added to diets must take this into account. If this is not considered, the canine NRC safe upper limit (370 mg of EPA+ DHA/kg $^{0.75}$) can be exceeded, leading to potential gastrointestinal signs and platelet dysfunction, bruising and bleeding.

Medium chain triglycerides (MCT): MCTs especially when combined with antioxidants have shown a benefit in helping dogs with cognitive dysfunction. As many as 20% to 68% of middle-aged to elderly dogs are thought to experience cognitive dysfunction or behavioral changes, which can manifest in varying degrees of mental decline (Pan 2018)

Nutritional Balance

Healthy senior pets are more vulnerable to nutritional imbalances and less tolerant of deficiencies and excesses. This makes it even more important to ensure that the majority (≥ 90%) of a senior pet's diet is made up of a diet or homemade formula balanced to meet the unique energy and nutrient needs of the individual senior pet. Sharing human foods and treats with pets is an important part of the human animal bond, however it is easy to exceed 10% of the daily caloric requirement with these additional foods. Choosing complete and balanced treats and foods can preserve both the family-pet bond and the pet's nutritional balance.

Dietary supplements

A key consideration when using nutraceutical supplements is for their efficacy, optimal dosing and potential nutrient interactions. This information may not be well established. Any nutritional care plan should begin with a thorough patient assessment, evaluating the calorie and nutrient needs for the pet's life stage and health status, and identifying the target nutraceutical and desired dose. When deciding between a diet that already includes the nutraceutical or prescribing it as a separate supplement, two factors must be evaluated:

a) the nutrient profile of the base diet and the concentration of the nutraceutical in the formula, and

b) the quality, composition and caloric content of the standalone supplement.

Incorporating a nutraceutical into a complete and balanced diet helps ensure that calories are accounted for and nutrient balance is maintained. These diets are generally well accepted, and it avoids the challenges of administering capsules, tablets or liquids. However, the feeding amount required to meet a pet's energy needs must also deliver the intended nutraceutical dose. If it does not, an alternative diet or an additional supplement may be necessary.

Administering supplements separately allows for more precise control of dosing and avoids reliance on food intake. Yet, this approach carries disadvantages, such as added calories contributed from the supplement themselves or the vehicle pet owners use to administer them. This can lead to nutritional imbalance and to unhealthy weight gain. Product quality varies widely. In the United States, manufacturers are responsible for ensuring safety and labeling, so prescribers and clients should choose products from reputable companies with strong quality assurance.

Navigating the Challenges of Comorbidities

A general approach to nutritional planning in pets with multiple conditions is to use a "nutritional triage" process that prioritizes needs based on both medical and nutritional considerations. The first step is to identify nutrients of concern and ensure that the diet meets the fundamental requirements for the species and life stage, including the senior life stage. Next, clinicians should consider the onset of each condition, distinguishing between acute and chronic problems, and then prioritize those that most directly affect clinical signs, quality of life or severity of disease. Conditions with the greatest impact on prognosis or those that are progressive should be addressed next. From this assessment, a "nutrient profile wish list" can be developed, incorporating the dietary features needed for management of each condition while recognizing contraindications or intolerances. When conflicts exist, a balance must be struck, with priority given to the condition most critical to patient welfare. **Table 1** lists ranges for typical nutrient adjustment for managing comorbidities, which can guide practical adjustments and product selection. Based on this prioritization, the clinician selects a therapeutic diet or, when necessary, consults a board-certified veterinary nutritionist for a customized formulation.

The final step is to make a clear, specific nutritional recommendation, including the exact product, form and flavor; the amount and frequency to feed; and a monitoring or follow-up plan. For example, an overweight senior cat or dog with early kidney disease may benefit from a modestly high-protein, lower-phosphorus diet. In such cases, caloric restriction is often required, making careful adjustment of protein levels critical to ensure needs are met. Once a therapeutic plan is implemented, the patient should be monitored closely to confirm that outcomes are achieved, with repeated nutritional assessments and iterative modifications as needed.

Because senior pets now represent a significant proportion of the pet population, clinicians should adopt a proactive preventive approach to nutritional assessment, monitoring and adjustments. More frequent health and nutrition screening in middle age pets enables earlier disease detection and timely intervention. Nutrition plays a central role in supporting the health and well-being of aging pets, from preserving LBM to reducing the risk of frailty, morbidity and loss of quality of life. An individualized approach grounded in maintaining optimal body weight and condition with complete and balanced nutrition provides the foundation for preventive care and promotes healthspan. For healthy senior dogs and cats, higher dietary protein intake can help mitigate age-related LBM loss, while beneficial fats, antioxidants and other targeted nutrients may further support mobility, cognition and overall function. Continued research is needed to refine nutrient requirements and identify strategies that prevent or delay sarcopenia and other age-related conditions, ensuring that nutrition remains a powerful tool in maximizing both lifespan and quality of life for senior and geriatric pets.

Table 1: Reference Values to Assess Dog and Cat Diets with Nutrient Modifications

Nutrient to be Modified (Enriched or Restricted)	AAFCO* minimum g or mg/100 kcal	Low g or mg/100 kcal	Moderate g or mg/100 kcal	High g or mg/100 kcal
Protein - Dog	4.5 g/100 kcal	<5 g/100 kcal	6-7 g/100 kcal	≥ 9 g/100 kcal
Protein - Cat	6.5 g/100 kcal	< 7 g/100 kcal	7-8 g/100 kcal	≥ 10 g/100 kcal
Fat - Dog	1.4 g/100 kcal	≤ 2 g/100 kcal ultra-low	2.5-3.5 g/100 kcal	≥ 5 g/100 kcal
Fat - Cat	2.3 g/100 kcal	≤ 3 g/100 kcal	4-5 g/100 kcal	> 5 g/100 kcal
Crude Fiber - Dog	NA	< 1.0 g/100 kcal	1.0-2.0 g/100 kcal	> 2.0 g/100 kcal
Crude Fiber - Cat	NA	< 0.5 g/100 kcal	0.5-1.0 g/100 kcal	> 1.0 g/100 kcal
Fiber (TDF) - Dog	NA	< 2.0 g/100 kcal	2-4 g/100 kcal	> 1.0 g/100 kcal
Fiber (TDF) - Cat	NA	< 0.5 g/100 kcal	1.0-2.5g/100 kcal	> 2.5 g/100 kcal
Phosphorus - Dog	100 mg/100 kcal	< 100 mg /100 kcal	<150 mg/100 kcal	>200 mg/100 kcal
Phosphorus - Cat	125 mg/100 kcal	< 125 mg /100 kcal ultra-low	<160 mg/100 kcal low	>200 mg/100 kcal
Sodium - Dog	20 mg/100 kcal	< 70 mg /100 kcal ultra-low	<100 mg/100 kcal low	>250 mg/100 kcal
Sodium - Cat	50 mg/100 kcal	< 70 mg /100 kcal ultra-low	<100 mg/100 kcal low	>250 mg/100 kcal
EPA&DHA - Dog (mg of combined)	NA	NA	~ 10-15 mg/100 kcal	≥ 15 mg/100 kcal [wide variation]
EPA&DHA - Cat (mg of combined)	NA	NA		≥ 15 mg/100 kcal [wide variation]
Copper - Dog	0.125 mg/100 kcal	≤0.15 mg /100 kcal	0.15-0.375 mg/100 kcal	0.38-0.62 mg/100 kcal [controversial]
Copper - Cat	0.125 mg/100 kcal	NA	NA	NA

For use as reference when selecting products to achieve nutrient modifications to either enrich or restrict a particular nutrient. This table presents AAFCO minimum levels for adult canine and feline maintenance and "typical" nutrient ranges of commercial pet foods.

c There are no currently established values for low, moderate, and high nutrient ranges. The specific ranges provided in this table are based on the author's opinions and clinical experience with commercially available foods.

*Association of American Feed Control Officials 2020 Official Publication for canine or feline adult maintenance minimums.

Adapted from Churchill, J.A., 2025. Nutritional support of geriatric dogs and cats and palliative care patients. In: C. Lenox, J. Stockman and C. Villaverde, *eds. Purina Institute Handbook of Canine and Feline Well-Pet Nutrition: A Reference Guide to Nutritional Management of Healthy Dogs and Cats. 1st ed.*

Note

Dr Julie Churchill has presented two webinars for CIVT which can be purchased as recordings to view on demand. '**Feeding Seniors for Life - Geriatric Nutrition'** will teach you how to perform a nutritional assessment of senior dogs and make nutritional recommendations, you will also be able to address common conditions of senior dogs through nutritional management. **'Canine Obesity Management - More Than Just Trimming the Fat'** will teach you how to create individualized nutritional plans that will not only improve the health of your patients but also your relationship with and satisfaction of clients. Please click HERE to find out more.

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ARTICLE

Interpreting Pet Food Labels: A Mathematical Approach to Nutrient Bases

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Introduction

Nutrition labels present a collection of quantitative summaries, where each percentage represents a ratio of nutrient concentration to a specified reference variable — such as food mass, moisture level or energy density. Because pet food products vary widely in both moisture content and energy density, these reference variables are not interchangeable. Mathematics allows direct comparison of nutrient concentrations between products, even when they appear very different at first glance.

Each basis — as-fed (AF), dry matter (DM) or caloric (C) — uses a unique denominator that fundamentally changes how the same underlying nutrient composition is perceived. The choice of denominator determines the apparent value of a nutrient's concentration. For example, a product that appears lower in protein may only appear that way because its denominator includes water weight or because it reflects a different energy density.

Understanding which denominator is used and how to convert among them is fundamental to interpreting pet food labels (Case et al. 2011). Through basic algebraic conversions and ratio logic, these bases can be transformed to provide meaningful comparisons across product types.

The sections that follow develop a mathematical framework for understanding how the denominator affects apparent nutrient concentration and how algebraic transformations enable accurate comparisons across different types of pet food.

Understanding Nutrient Bases

Each basis represents the same nutritional composition viewed through a different mathematical lens. This distinction lies entirely in the denominator — the reference quantity to which the nutrient amount is compared (Case et al. 2011). Nutrient concentration can be represented generally as:

$$Nutrient\ \ concentration\ \ = \frac{Nutrient\ \ amount}{Reference\ \ variable}$$

The reference variable in the denominator defines whether the nutrient concentration is expressed per total food weight, dry-matter weight or per unit of energy. Changing the denominator alters the apparent value of the nutrient, even though the nutrient's actual quantity in the food remains constant. This denominator effect is a common source of confusion in interpreting pet food labels (FEDIAF 2024).

For example, a canned food with high moisture may list a protein content of only 10% on an as-fed basis, while a dry kibble may list a protein content of 30%. Without adjusting for water weight, the kibble appears to be three times richer in protein, yet its dry-matter protein content may be similar. This is because water contributes mass but no nutrients. When water constitutes a large proportion of total food mass (as in canned products), it increases the denominator in the as-fed calculation while contributing nothing to the numerator. This reduces the apparent nutrient concentration without altering the actual amount of nutrients available in the food's dry portion.

Understanding dimensional consistency—ensuring that units in calculations are compatible—is essential when working with nutrient bases. Each nutrient concentration must maintain dimensional integrity, meaning the units of the numerator must be appropriately scaled to the units of the denominator.

For instance, when expressing protein content, if the numerator is given in grams and the denominator is

given in kilograms, the resulting concentration has units of grams per kilogram (g/kg), which can be converted to a percentage by dividing by 10. To see why, consider that 1 kilogram equals 1,000 grams. If a food contains 10 grams of protein per 1 kilogram (1,000 g) of food, this can be written as 10 grams per 1,000 grams. Dividing both the numerator and denominator by 10 gives 1 gram per 100 grams, which is the definition of 1%. Therefore, 10 g/kg equals 1%.

This concept becomes particularly important when converting between bases. Maintaining consistent units prevents scaling errors that distort nutrient concentrations, ensuring accurate representation of nutrient levels. With this dimensional framework established, the specific mathematical properties of each basis can now be examined.

The As-Fed Basis

The as-fed (AF) basis expresses nutrient amounts relative to the product's total weight, including water and dry matter. The denominator in this basis is the food's total mass. This is the form required by labeling regulations, such as the Association of American Feed Control Officials (AAFCO 2024), which specifies that guaranteed analyses must reflect the food as it is sold and consumed.

The nutrient concentration on an as-fed basis can be mathematically represented as:

$$Nutrient_{AF} = \frac{Nutrient\ \ mass}{Total\ \ food\ \ mass} \times 100$$

In the equation above, multiplying by 100 converts the resulting decimal fraction to a percentage. As-fed nutrient values are also frequently expressed in units of grams per kilogram (g/kg) or milligrams per kilogram (mg/kg). To convert from a percentage to g/kg, multiply by 10:

$$Nutrient_{AF}\ \ (\mathrm{g/kg}) = \ \ Nutrient_{AF}\ \ (\%) \times 10$$

For example, a protein value of 12% on an as-fed basis equals 120 g/kg.

Because the denominator includes the weight of water, and water contributes to total weight but contains no nutrients, it dilutes the apparent concentration of nutrients when expressed on this basis (NRC 2006). For example, if 100 g of canned food contains 75 g of water and 12 g of protein, then:

$$Protein_{AF} = \frac{12}{100} \times 100 = 12\%$$

This value represents the nutrient as a percentage of the total mass. However, it does not account for the fact that 75% of that mass is water, which provides no nutritional contribution.

Different forms of pet food can vary drastically in moisture content. Dry kibble typically contains approximately 10% moisture, whereas canned or fresh diets can contain 60-80% moisture (U.S. Food and Drug Administration 2020). Because of this discrepancy, nutrient values are not directly comparable on an as-fed basis between products with different moisture content.

For example, a dry kibble with 30% protein on an as-fed basis and 10% moisture appears to have far more protein than a canned food with 12% protein on an as-fed basis and 75% moisture. However, this comparison is misleading because it does not account for the moisture discrepancy between the products, as demonstrated in the dry-matter basis section below.

The Dry-Matter Basis

The dry-matter (DM) basis expresses nutrient quantities relative to the product's dry matter, excluding water entirely. Dry matter is defined as the portion of food remaining after all moisture has been removed. Algebraically, this means changing the denominator from total mass to dry-matter mass only. Because nutrients are present only in food's dry matter, this basis provides a more consistent measure of nutrient density across products with varying water content (Case et al. 2011).

To convert nutrient values from as-fed to dry matter, the following equation is used:

$$Nutrient_{DM} = \frac{Nutrient_{AF}}{100 - Moisture_{AF}} \times 100$$

This equation requires that both nutrient and moisture values are expressed as percentages on an as-fed basis. The term (100 - $Moisture_{AF}$) represents the percentage of dry matter in the product.

Here, the denominator is dry-matter mass — the fraction of the food that contains nutrients. Dry-matter mass is a fraction of the entire product, meaning it is a smaller value than the total food mass. This change in the denominator alters the apparent nutrient density, not by changing the nutrient content, but by changing the definition of "100%."

Dividing by the smaller dry-matter mass rather than the larger total mass (as in the as-fed basis) results in a higher percentage. This increase reflects the actual concentration of nutrients in the portion of the food that contains them. This approach eliminates moisture as a confounding variable (Case et al. 2011).

To understand why this conversion works, it is helpful to consider the dimensional analysis:

$$\frac{Nutrient_{AF} \ (\%)}{100 - Moisture_{AF}} \times 100$$

Which expands to:

$$\frac{grams \ of \ nutruent \ per \ 100 \ grams \ of \ food}{grams \ of \ dry \ matter \ per \ 100 \ grams \ of \ food} \times 100$$

The "per 100 grams of food" terms cancel out, resulting in:

$$\frac{grams \ of \ nutrient}{grams \ of \ dry \ matter} \times 100 = \% \ \text{DM}$$

This yields nutrient concentration expressed as grams per 100 grams of dry matter, which is the definition of dry-matter percentage.

Returning to the previous example, suppose a canned food contains 75% moisture with 12% protein, and a dry kibble contains 10% moisture with 30% protein.

To calculate the dry-matter protein percentages of the canned food and dry kibble, the dry-matter conversion equation can be applied:

$$Protein_{DM,canned} = \frac{12}{100 - 75} \times 100 = 48\%$$

$$Protein_{DM,dry} = \frac{30}{100 - 10} \times 100 = 33.33\%$$

Although the canned food appears to have a lower protein percentage on the label (12% vs. 30%), on a dry-matter basis, it actually contains 48% protein, compared to 33% in the kibble.

Converting from Dry-Matter to As-Fed Basis

While the primary need is often to convert from as-fed to dry-matter, the reverse conversion is equally important.

Dry matter values can be converted to an as-fed basis by rearranging the previous equation:

$$Nutrient_{AF} = Nutrient_{DM} \times \frac{100 - Moisture_{AF}}{100}$$

The term $\frac{100 - Moisture_{AF}}{100}$ represents the decimal fraction of the product that is dry matter. Multiplying the dry-matter nutrient concentration by this fraction reintroduces the moisture dilution, scaling the nutrient percentage back down to reflect its concentration in the total food mass.

Suppose a gently cooked, fresh diet contains 60% protein on a dry-matter basis and 65% moisture. To find the as-fed protein percentage, the above equation can be used:

$$Protein_{AF} = 60 \times \frac{100 - 65}{100} = 21\%$$

This calculation shows that a product with 60% protein on a dry-matter basis would display only 21% protein on its guaranteed analysis panel when the product contains 65% moisture. This significant reduction demonstrates the impact of moisture on as-fed values and underscores the importance of accounting for moisture content when interpreting pet food labels.

The Caloric Basis

While the dry-matter basis allows for a direct comparison of nutrient density by eliminating the effect of moisture, it does not account for energy density — the amount of metabolizable energy contained per unit of food. Energy density can vary substantially among products, meaning even if two products have identical nutrient percentages on a dry-matter basis, the nutrients delivered per calorie consumed can differ significantly. The caloric basis shifts the denominator from mass to energy.

The following equation can be used to convert as-fed nutrient concentrations to a caloric basis:

$$Nutrient_c = \frac{Nutrient_{AF}}{Energy\ \ density} \times 1{,}000$$

It is important to note that the numerator and denominator in the above equation must be expressed in the same unit system. For example, if the numerator represents grams of a nutrient per kilogram of food, and the denominator represents kilocalories per kilogram, both quantities are scaled relative to one kilogram. This maintains dimensional consistency and ensures that the resulting value correctly expresses nutrient density relative to energy intake. However, if protein is expressed as a percentage (g per 100 g) but energy density is given in kcal/kg, the calculation cannot proceed correctly because the quantities refer to different amounts of food. Both must first be converted to per kilogram before continuing to calculate the nutrient concentration.

When both quantities are per kilogram, the kilogram units cancel, leaving:

$$\frac{g\ \ nutrient}{kcal} \quad \times 1{,}000 = \frac{g\ \ nutrient}{1{,}000\ \ kcal}$$

Multiplying by 1,000 scales the result to a more practical reporting unit — grams of nutrient per 1,000 kcal (g/1,000 kcal) rather than per 1 kcal.

Two foods with identical nutrient concentrations on an as-fed or dry-matter basis may deliver different amounts of nutrients when consumed to meet their daily energy needs because animals regulate food intake based on energy requirements rather than food mass (Case et al. 2011). A food with higher energy density satisfies energy needs with less food consumed, while a food with lower energy density requires greater intake to meet the same energy requirement. However, the nutrients delivered per calorie depend on how the food was formulated: a high-energy-density diet can be formulated to provide the same nutrient concentration per calorie as a lower-energy-density diet, or it may differ substantially.

Returning to our previous example: suppose a dry kibble contains 30% protein on a dry-matter basis with 10% moisture and 3,500 kcal/kg, and a canned food contains 48% protein on a dry-matter basis with 75% moisture and 1,500 kcal/kg. To calculate the protein value on a caloric basis:

(1) Convert dry-matter protein to as-fed

$$Protein_{AF,canned} = 48 \times \frac{100 - 75}{100} = 12\%$$

$$Protein_{AF,dry} = 30 \times \frac{100 - 10}{100} = 27\%$$

(2) Convert as-fed protein units from % to g/kg

$$Protein_{AF,canned} = 12 \times \quad 10 = 120\frac{g}{kg}$$

$$Protein_{AF,dry} = 27 \times \quad 10 = 270\frac{g}{kg}$$

(3) Convert to caloric basis

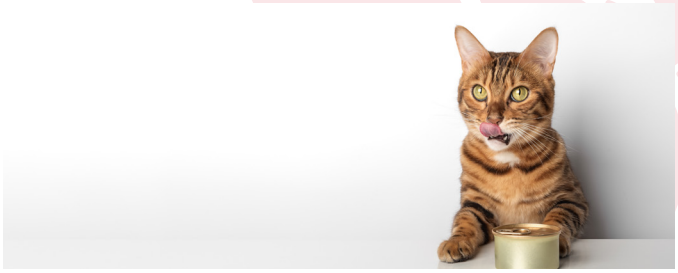
$$Protein_{C,canned} = \frac{120}{1500} \times 1{,}000 = 80\frac{\text{g}}{1{,}000\ \ kcal}$$

$$Protein_{C,dry} = \frac{270}{3500} \times 1{,}000 = 77.14\frac{\text{g}}{1{,}000\ \ kcal}$$

On a dry-matter basis, the canned food appears substantially higher in protein (48% vs. 30%). However, on a caloric basis, the two products deliver similar amounts of protein: 80 g/1,000 kcal for the canned food versus 77.14 g/1,000 kcal for the kibble.

This similarity exists because the canned food, despite having a higher protein concentration per gram of dry matter, has much lower energy density. Animals must consume more of the canned food to meet their energy requirements, which offsets the difference in concentration. The caloric basis shows that both products would deliver approximately the same amount of protein when animals consume enough of each food to meet the same energy requirement.

Applying All Three Bases



Having examined each basis individually, a direct comparison across multiple product types demonstrates how these conversions work together in practice. Consider four different types of pet food with the following specifications:

Product	Moisture (%)	$Protein_{AF}$ (%)	Energy Density (kcal/kg)
Dry Kibble	12	27	3,800
Canned Food	76	10	1,000
Fresh/Cooked	68	15	1,300
Freeze-Dried	5	43	4,200

Using the conversion equations developed throughout this paper, protein content can be calculated across all three bases. The dry-matter conversions follow the equation introduced earlier:

$$\text{Protein}_{\text{DM}} = \frac{\text{Protein}_{\text{AF}}}{100 - \text{Moisture}_{\text{AF}}} \times 100$$

For the caloric basis, the as-fed values are first converted to g/kg, then divided by energy density and multiplied by 1,000:

$$\text{Protein}_{\text{C}} = \frac{\text{Protein}_{\text{AF}}\text{x}10}{\text{Energy density}} \times 1{,}000$$

Applying these conversions:

$$Protein_{DM,kibble} = \frac{27}{100-12} \times 100 = 30.68\%$$

$$Protein_{DM,canned} = \frac{10}{100-76} \times 100 = 41.67\%$$

$$Protein_{DM,fresh} = \frac{15}{100-68} \times 100 = 46.875\%$$

$$Protein_{DM,freeze-dried} = \frac{43}{100-5} \times 100 = 45.26\%$$

$$Protein_{C,kibble} = \frac{27\text{x}10}{3{,}800} \times 1{,}000 = 71.05 \frac{\text{g}}{1{,}000 \quad kcal}$$

$$Protein_{C,fresh} = \frac{15\text{x}10}{1{,}300} \times 1{,}000 = 115.38 \frac{\text{g}}{1{,}000 \quad kcal}$$

$$Protein_{C,canned} = \frac{10\text{x}10}{1{,}000} \times 1{,}000 = 100 \frac{\text{g}}{1{,}000 \quad kcal}$$

$$Protein_{C,freeze-dried} = \frac{43\text{x}10}{4{,}200} \times 1{,}000 = 102.38 \frac{\text{g}}{1{,}000 \quad kcal}$$

These calculations yield the following comparison:

Product	$Protein_{AF}$ (%)	$Protein_{DM}$ (%)	$Protein_{C}$ ($\frac{\text{g}}{1{,}000\text{kcal}}$)
Dry Kibble	27	30.68	71.05
Canned Food	10	41.67	100
Fresh/Cooked	15	46.875	115.38
Freeze-Dried	43	45.26	102.38

These conversions reveal important insights that are hard to see from as-fed values alone. The freeze-dried food appears to contain more than four times the protein of the canned food, when comparing as-fed percentages (43% vs. 10%). However, on a dry-matter basis, these products have relatively similar protein concentrations (45.26% vs. 41.67%). On a caloric basis, they deliver nearly the same amount of protein per 1,000 kcal consumed (102.38 g/1,000 kcal vs. 100 g/1,000 kcal).

Similarly, the fresh food shows the second-lowest protein content on an as-fed basis (15%), yet it delivers the highest protein per calorie (115.38 g/1,000 kcal)—over 60% more than the kibble. This occurs because the fresh food has a relatively low energy density. To meet their daily caloric requirements, animals must consume a greater mass of this food. Since the water in the food contributes no calories, the animal consumes proportionally more of the nutrient-containing dry matter, thereby increasing total protein intake per unit of energy.

The dry-matter basis reveals that three of the four products have similar protein concentrations (41–47%), while the kibble is notably lower (30.68%). Accounting for energy density shows that the kibble delivers the least protein per unit of energy intake, despite having the second highest as-fed percentage.

When to Use Each Basis

Each basis serves a distinct analytical purpose by changing the denominator to reveal different aspects of nutrient composition. The selection of an appropriate nutrient basis depends on the specific comparison being made.

The as-fed basis is best suited for evaluating the product exactly as it will be consumed. Because labeling regulations require guaranteed analyses to reflect the product in its purchased form (AAFCO 2024), the as-fed basis remains the standard format for product labels. This basis is also useful when calculating feeding portions, as instructions must correspond to the product's total weight, including moisture. However, the as-fed basis should not be used to compare nutrient concentrations between products with different moisture contents, as water mass obscures true nutrient density.

The dry-matter basis is best suited for comparing nutrient concentrations across products with varying moisture levels. By excluding water from the denominator, this basis enables direct comparison of nutrient density regardless of product form (Case et al. 2011). This basis is particularly valuable for evaluating whether a food meets minimum nutrient requirements or for identifying differences in nutrient concentration between product forms. However, it does not account for energy requirements and therefore does not reflect nutrient delivery in practice.

The caloric basis evaluates nutrient delivery when food is consumed to meet daily energy needs. Because animals regulate food intake primarily by energy requirements rather than by mass (Case et al. 2011), the caloric basis most accurately reflects nutrient intake in practice. This basis is essential when comparing foods with substantially different energy densities or when assessing whether a product provides adequate nutrients at typical feeding amounts.

In practice, a complete nutritional evaluation often requires examining all three bases sequentially. The as-fed basis reflects regulatory requirements and represents the product as purchased. The dry-matter basis reveals whether apparent differences represent true compositional differences or result from moisture variation. The caloric basis determines whether those differences translate to meaningful nutrient delivery when animals consume food to meet energy requirements. Each basis provides a different mathematical perspective on the same nutritional composition, and selecting the appropriate basis—or combination of bases—depends on the analytical objective.

Conclusion

Each nutrient basis—as-fed (AF), dry matter (DM), and caloric (C)—describes the same nutritional composition using a different reference variable in the denominator. As established throughout this paper, the denominator fundamentally determines how nutrient concentration appears, even though the actual quantity of nutrients remains constant. Understanding the mathematical relationships between these bases is essential for accurately comparing different forms of pet food.

The as-fed basis uses total food mass as its reference variable. This is the format required on pet food labels, guaranteed analysis panels, and product feeding instructions because it reflects the product exactly as it is purchased and consumed (AAFCO 2024). However, because water contributes weight

without providing nutrients, it dilutes the apparent nutrient concentration. The dry-matter basis removes moisture as a confounding variable by changing the denominator from total mass to dry-matter mass alone, revealing the actual nutrient concentration in the food (Case et al. 2011). While this basis allows direct comparison among foods with varying moisture levels, it does not account for differences in energy density. The caloric basis addresses this by changing the denominator from mass to energy density. By expressing nutrients per unit of metabolizable energy rather than per unit of mass, this basis reflects how animals actually use food, not just how it is measured in the bowl.

The algebraic conversions outlined in this paper are simple yet powerful: recognizing that every percentage represents a ratio with a specific denominator and understanding how changing that denominator affects apparent concentration allows for accurate interpretation of pet food composition. Selecting the appropriate basis—or using all three in sequence—depends on the comparison being made. By identifying the denominator, ensuring dimensional consistency, and converting nutrients to a common basis, one can move beyond surface-level percentages to assess the true nutritional value of pet food.

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ARTICLE

Overweight or Nutrient Deficient: The Dilemma in Feeding Less Active Pets

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Introduction

Obesity and overweight are endemic in dogs and cats - 59% of dogs and 61% of cats are affected, according to a 2022 study (Association for Pet Obesity Prevention n.d.). In addition, pets' average activity levels continue to decline, so that the typical dog or cat has a significantly lower activity level than in years past (O'Rourke et al. 2025; Jewell and Jackson 2023). Pet owners utilize many strategies to help their animals either lose weight or prevent weight gain. They may encounter obstacles to success, including begging or other unwanted food-related behaviors, and/or unintended adverse outcomes, such as nutritional deficiencies and potential health consequences, from some of these strategies (Gaylord 2017). The current nutritional standards for dogs and cats assume high calorie intake (National Research Council 2006; AAFCO 2024), which perpetuates this problem. However, diets can be properly formulated to supply adequate nutrients along with appropriate calories for an individual animal's activity level and energy needs.

Factors Contributing to Excess Weight in Dogs and Cats

Weight gain may occur because of excess energy intake or decreased energy expenditure. However, metabolic and endocrine dynamics impact both intake and expenditure of energy (Wakshlag & Loftus 2014), so determining ideal energy intake for any individual animal may be complex. Considerations may include the food type, recommended feeding directions for the specific food, any additional treats or other foods in the pet's diet, whether there is structured exercise in the pet's routine, lifestyle, spay/neuter status, the presence or absence of other pets in the home, environmental conditions, health status and other factors when estimating energy needs.

Obesity Has Significant Health Consequences

Just as humans face increased risk of a number of health conditions as their weight climbs above ideal, the same is true for companion animals. Osteoarthritis, diabetes mellitus and insulin resistance, skin disease, renal disease, urolithiasis and neoplasia have been implicated with obesity in dogs and/or cats (Wakshlag & Loftus 2014). These conditions place a physiologic burden on the animal, as well as financial, logistical, and emotional burdens on the pet owner. Conversely, calorie restriction is associated with an increase in longevity in dogs (Kealy et al. 2002). Therefore, maintaining ideal body condition in pets is a valuable strategy for maximizing quality of life as well as fostering the human-animal bond.

Weight Loss Practices and Pitfalls

Pet owners employ various tactics toward achieving weight loss in their pets. These may be owner-initiated or recommended by the veterinarian, and may include eliminating or reducing treats, increasing exercise, feeding a "light" diet or therapeutic weight loss diet or decreasing the amount fed of the pet's regular diet.

When pets are not satiated, behaviors like begging, constantly looking for food and stealing food from other pets or humans can make diet plan compliance difficult for pet owners. In addition, if all members of the household are not committed to the pet's weight loss plan, the pet may continue to receive treats or larger meal portions that make weight loss unlikely.

Nutritional Deficiencies During Weight Loss

While therapeutic veterinary diets are formulated for weight loss purposes, and so are intended to contain adequate nutrients to meet the needs of dogs and cats when delivered in fewer calories, the same is not true of most over-the-counter diets.

An overview of how commercial maintenance diets are formulated illustrates why they may not be nutritionally complete for weight loss or for feeding low activity pets. Both the National Research Council (2006) and the American Association of Feed Control Officials (AAFCO 2024) have set caloric nutrient profiles for dogs and cats for various life stages. Caloric profiles list the minimum (and in some cases, maximum) amount of each essential nutrient that must be present in every 1000 kilocalories (kcal) of the diet. NRC set these amounts based on the metabolic requirement of each nutrient (amount of the nutrient per day needed per metabolic body weight, which in dogs is body weight in $kg^{0.75}$), as well as on the assumption that animals will consume a given number of kilocalories per metabolic body weight. In the dog, this calorie assumption is 130 x $kg^{0.75}$ for adult maintenance. As an example, a 50 lb adult dog has a metabolic body weight of $22.73^{0.75}$kg, or 10.4 kg. This dog would be expected to consume 130 x 10.4 = 1,352 kcal/day. When the dog consumes 1,352 kcal of a diet formulated to meet the NRC caloric nutrient recommendations for adult dogs, the dog will consume adequate nutrients. But if the dog consumes fewer than 1,352 kcal of this diet, the dog may be consuming less than the recommended allowance for some or all nutrients.

AAFCO set their nutrient profiles based on NRC recommendations, and their calorie assumption for maintenance of adult dogs to meet those recommendations equates to 132 x $kg^{0.75}$, slightly higher than NRC. So the 50 lb dog in the above example would need to consume 132 x 10.4 = 1,373 kcal per day of a diet formulated to the AAFCO caloric nutrient profile to meet its nutrient needs. AAFCO's adult cat nutrient profile is similar to NRC for most, but not all nutrients. AAFCO does not offer any guidance about caloric intake needed to meet nutrient needs, but based on the similarity to the NRC profile, it may be assumed that both are based on the energy intake assumption defined by NRC: 100 x $kg^{0.67}$. This equation yields 276 kcal/day for an adult cat weighing 10 lb, and the cat must consume 276 kcal in order to consume recommended amounts of essential nutrients. Foods in the United States are formulated to AAFCO nutrient profile standards, and these standards are in relatively wide use in other areas around the world.

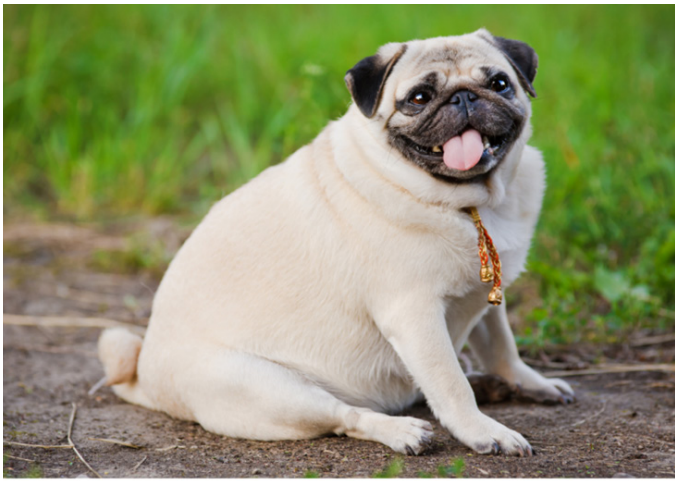
If the feeding directions on a commercial food do not direct pet owners to feed the number of kilocalories that align with the caloric profile (and its associated energy intake assumption) to which the food was formulated, adequate nutrients may not be delivered. Similarly, if a pet owner decides to feed less than recommended by the manufacturer, or if the veterinarian directs the pet owner to feed less, adequate nutrients may not be delivered.

Gaylord, Remillard and Saker (2014) found that US adult maintenance and over-the-counter weight management diets (often called "light" diets) - but not therapeutic veterinary weight loss diets - were often deficient in several nutrients when fed at energy intake levels needed to produce weight loss. These nutrients included choline, selenium, some B vitamins, omega-3 fatty acids and some amino acids.

Another study (Olivindo et al. 2022) found that even veterinary therapeutic weight loss diets in Brazil had nutrient deficiencies when fed at manufacturer intake recommendations.

The problem is not restricted to pets undergoing weight loss, however. Depending on the formulation of the diet, deficiencies may also be present if the diet is fed at reduced amounts aimed at preventing a lower-activity animal from gaining weight. The energy intake assumptions by NRC and AAFCO are far higher than the average dog or cat actually requires (O'Rourke et al. 2025; Jewell & Jackson 2023), so a large percentage of the pet population is not well-served by the current caloric nutrient

profiles that are designed for extremely highly active pets. When less active pets eat at the energy intake level required to meet nutrient needs, they are at great risk of becoming overweight; if they eat at the appropriate energy intake level for their activity level, they are at risk of nutrient deficiencies.



Consequences of Nutritional Deficiencies

While overt disease may not be obvious in the short term with many nutritional deficiencies, some could become clinically significant quickly. One study (Abel et al.1979) found that dogs on a protein-deficient calorie restriction diet plan over a seven week period experienced decreased heart function and myofiber atrophy.

Furthermore, some breeds may have higher requirements for specific amino acids than the values reflected in NRC's metabolic requirements. Mansilla et al. (2020) found differences between the methionine requirement for Dachshunds versus that of Beagles and Labrador Retrievers, where Dachshunds' requirement aligned with the NRC minimum for methionine while the Beagles and Labrador Retrievers had higher requirements compared to the NRC. This suggests that there may be some breeds at higher risk of nutritional deficiencies when fed at less than the formulated energy intake assumption. It also raises additional questions about the role of nutritional deficiencies from feeding less than recommended amounts in the recent dilated cardiomyopathy crisis.

Fresh meat-based diets are often high in protein, but ultra-processed pet food diets generally have lower overall protein content in comparison, and so may be associated with a higher risk of amino acid deficiency when fed at lower energy intake.

Micronutrient deficiencies are often not recognized clinically but could contribute to chronic disease. In cats, potassium deficiency over time has been linked to potential renal dysfunction (German et al. 2023). While fresh meat-based diets typically meet even relatively low-activity pets' protein needs, they could present a higher risk of deficiencies of some micronutrients, such as potassium. In particular, when whole foods are utilized to meet nutrient needs, there is often not a significant safety margin between the AAFCO minimum nutrient requirement and the as fed nutrient content of the diet. When the diet is fed at lower energy intake than the energy intake assumption to which the diet is formulated, daily micronutrient consumption can be deficient. In contrast, ultra-processed foods often contain vitamin and mineral premixes that supply micronutrients in high levels, where excess may be of greater concern than deficiency in some cases, although micronutrient deficiencies may also exist when these foods are fed to low-activity animals.

Although there is a dearth of information on the effects of nutrient deficiencies during weight loss diets in animals, there are established metabolic requirements for each essential nutrient (NRC 2006). It seems prudent to ensure these requirements are met, even during weight loss. Moreover, the many animals with an activity level below the energy intake assumption of AAFCO and NRC caloric nutrient profiles may be chronically deficient in several nutrients when eating commercially available pet foods at lower energy intake levels. It is reasonable to speculate that chronic nutrient deficiencies may contribute to chronic disease. More research is needed to identify potential links between disease development in lower activity animals and their long-term consumption of less than the established recommended allowance of essential nutrients.

Do Nutritional Deficiencies Interfere with Weight Loss Efforts?

There is limited research in pets regarding nutrient deficiencies and the connection with weight gain or loss, but choline demonstrates lipotropic action in dogs (Germán David Mendoza-Martínez et al. 2022) and so may be helpful in aiding loss of excess body fat and/or preventing excess fat accumulation.

In the human literature, ensuring adequate levels of both B vitamins (Khamassi et al. 2025) and selenium (Cavedon et al. 2020) have been associated with improved weight loss for obese or overweight persons.

Given the difficulty that pet owners often experience in helping their pets lose weight, removing the potential obstacle of nutrient deficiencies may be a simple strategy to add to the weight loss plan. Additionally, protein and fiber have been shown to increase satiety and reduce food-seeking behaviors in dogs (Gaylord 2017), so ensuring adequate intake of all nutrients may assist pet owners in staying the course during the duration of the weight loss diet.

Diet Management for Lower Activity Pets

If a dog or cat successfully completes a weight loss diet, there is risk of gaining excess weight once they return to their regular diet, especially if the pet owner follows manufacturer feeding directions. However, feeding less often results in nutrient deficiencies.

Whether a pet has undergone weight loss or is at their ideal weight but is less active than the NRC/AAFCO energy intake assumption, careful diet evaluation is needed. The energy needs should be accurately assessed - with the understanding that any calorie requirement calculation is an estimation, and the energy needs should be reassessed often to adjust as needed - and a diet plan that provides adequate nutrients within the framework of appropriate calories should be developed for long term feeding.

There are many calorie recommendation equations in use, along with many activity level multipliers. Perhaps the most common starts with calculating the resting energy requirement (RER) as 70 x $kg^{0.75}$ for dogs and 70 x $kg^{0.67}$ for cats. This product is then multiplied by a factor assigned to an activity level to determine the MER, or maintenance energy requirement (Sanderson 2023). For example, an intact adult dog's calorie requirement might be 1.8 x RER. Animals undergoing weight loss might have multipliers less than one, such as 0.8 x RER.

However, recent studies that investigated caloric needs in dogs and cats suggest that the use of the multiplier 70 in calculating RER may overestimate caloric needs in today's pets (O'Rourke et al. 2025; Jewell & Jackson 2023).

Based on this apparent decrease in overall caloric requirements in the average dog and cat, the following activity levels with their corresponding multipliers may be more useful. Here, the caloric requirement calculation is simplified by using one multiplier, the K factor (named after Max Kleiber, who established the RER equation (Kleiber 1947) in popular use) to determine MER, rather than using the K factor 70 to determine RER followed by a second multiplier to determine MER. This is similar to the approach used by FEDIAF, the European pet food organization, which does recognize a nutrient profile for active adult dogs or cats, and another for less active adult dogs or cats (FEDIAF 2025). While this is a huge improvement over the one caloric profile (and lack of metabolic recommended allowances) that AAFCO provides, it remains limited in utility to the still relatively higher activity level than most pets of today. However, FEDIAF, like NRC, provides nutrient levels on a metabolic basis, allowing for formulation to accommodate any activity level.

Dog activity level descriptions and corresponding K factors for use in calculating energy requirement, where K factor x $kg^{0.75}$ = MER

Activity Level Label	K Factor $^{(0.75)}$	Type of activity
Adult - Weight loss	<65	
Adult - Inactive	65-70	Outside in fenced yard or on tie out >1 hour/day
Adult - Sedentary	70-75	Outside in fenced yard or on tie out 1-3 hours/day
Adult - Low activity	80-85	Low impact (walking, digging, pacing) 1 hour/day
FEDIAF Less active adult dog	95	
Adult - Active	90-100	Low impact (walking, digging, pacing) 1-3 hours/day
FEDIAF Active adult dog	110	
Adult - More Active	100-120	Vigorous activity (playing fetch/with other dogs, agility/other sports, swimming) for 1-3 hours/day OR paces anxiously >3 hours/day
NRC Adult dog	130	
AAFCO Adult dog	132	
Adult - Very Active	130-160	Vigorous activity (playing fetch/with other dogs, agility/other sports, swimming) for 3-6 hours/day OR caged laboratory dogs OR 1-3 hours/day in extreme environmental conditions
Adult - Working Dog	150-170	Strenuous activity (herding, hunting) for 3-6 hours/day
Adult - Sled Dog	860-1240	High activity under extreme environmental conditions – racing sled dogs in extreme cold

Cat activity level descriptions and corresponding K factors for use in calculating calories, where K factor x $kg^{0.67}$ = MER

Activity Level Label	K Factor $^{(0.75)}$	Type of activity
Adult indoor sedentary **spayed female 1-12 years**	50	Less than 30 minutes cumulative running/jumping/climbing/hunting per day
Adult indoor sedentary **intact female1-12 years**	53	Less than 30 minutes cumulative running/jumping/climbing/hunting per day
Adult Indoor Sedentary **neutered male 1-12 years**	55	Less than 30 minutes cumulative running/jumping/climbing/hunting per day
Adult indoor sedentary **intact male 1-12 years**	57	Less than 30 minutes cumulative running/jumping/climbing/hunting per day
Adult indoor **sedentary spayed female 12+ years**	62	Less than 30 minutes cumulative running/jumping/climbing/hunting per day
Adult Indoor Sedentary **neutered male 12+ years**	65	Less than 30 minutes cumulative running/jumping/climbing/hunting per day
Adult Indoor active **1-12 years**	75	More than 30 minutes cumulative running/jumping/climbing/hunting per day; or spends at 1-3 hours outside in extreme environmental conditions
FEDIAF less active	75	
Adult Indoor active **12+ years**	85	More than 30 minutes cumulative running/jumping/climbing/hunting per day; or spends 1-3 hours outside in extreme environmental conditions
Adult Outdoor Active **1-12 years**	100	Resides entirely outdoors or spends more than 3 hours outside in extreme environmental conditions
FEDIAF active	100	
NRC lean domestic cat*	100	
Adult Outdoor Active **12+ years**	120	Resides entirely outdoors or spends more than 3 hours outside in extreme environmental conditions

**NRC overweight domestic cat: 130 x $kg^{0.4}$ = MER*

Home prepared diets allow for customization to the energy and nutrient needs of the individual animal when they are properly formulated. Achieving this calorie-nutrient match cannot be accurately produced by guessing or estimating and depends on the use of specific ingredients in specific amounts. General-purpose recipes available online or from other sources may not provide the required nutrients in the appropriate number of calories, unless they are specifically formulated on a metabolic basis for less active pets.

If a commercial diet is used, it should be evaluated to determine the serving size that delivers the needed calories, and whether that serving size also delivers the metabolic recommended allowance for each essential nutrient. This can be challenging, if not impossible, if the food manufacturer will not supply a complete nutritional analysis of their product. Unfortunately, this is a common occurrence. Commercial diets can be formulated to address the needs of less active pets, but for the most part, manufacturers are not yet effectively doing so, even if the messaging on the label suggests it.

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CASE REPORT

Successful Management of Calcium Oxalate Urolithiasis using Western Herbal Medicine

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Abstract

Calcium oxalate (CaOx) uroliths in dogs often require surgical removal, carry a high recurrence risk, and arise from complex, multifactorial pathways. Secondary hyperparathyroidism (SHPT) contributes to CaOx formation by driving hypercalcemia, urinary calcium excretion and mineral deposition. Hyperadrenocorticism is a recognized cause of SHPT, yet occult or subclinical cortisol excess is rarely considered when routine endocrine tests are negative.

This case describes an eight-year-old Miniature Schnauzer with recurrent CaOx urolithiasis, persistent hepatopathy, hyperlipidemia and SHPT unresponsive to conventional therapy. Because occult hyperadrenocorticism was suspected as the upstream driver and lacks any established conventional treatment, an individualized, multi-phased Western herbal medicine protocol was implemented.

Treatment resulted in complete resolution of SHPT, clearance of CaOx uroliths without surgery, prevention of recurrence, and clinical improvement across endocrine, hepatic, metabolic and urinary parameters. These findings support a unified disease model in which subclinical cortisol excess may drive hyperlipidemia, oxidative stress, mineral imbalance and hepatopathy in predisposed breeds.

This case highlights the potential of Western herbal medicine as part of adaptive, hypothesis-driven integrative management in complex multi-systemic disease, particularly when conventional diagnostics yield incomplete explanations for clinical presentation.

Introduction

Calcium oxalate (CaOx) urolithiasis is a frequent cause of lower urinary tract disease in dogs, accounting for a large proportion of urolith submissions to veterinary laboratories (Osborne et al. 2009). These stones form when urine becomes supersaturated with calcium and oxalate ions, resulting in crystallization and aggregation (Bartges et al. 2006). Risk factors include genetic predisposition, dietary composition, urinary concentration and pH, and metabolic or endocrine disorders affecting calcium or oxalate excretion (Lulich et al. 2016).

Miniature Schnauzers are overrepresented among dogs with CaOx urolithiasis (Lekcharoensuk et al. 2000) and are also predisposed to idiopathic hyperlipidemia, characterized by persistently elevated serum cholesterol and triglycerides in the absence of overt endocrine disease (Xenoulis & Steiner 2010). Hyperlipidemia in this breed has been associated with vacuolar hepatopathy, gallbladder mucoceles, and, in some cases, subclinical pancreatitis (Watson 2016; Aguirre et al. 2018). Recent studies suggest that hyperlipidemia may not simply be a comorbidity but a potential driver of oxidative stress, metabolic inflammation and urinary stone risk, particularly when occurring alongside endocrine dysregulation such as occult hyperadrenocorticism (Paulin et al. 2022; Park et al. 2021; Xenoulis et al. 2021). Chronic cortisol excess—used synonymously here with occult hyperadrenocorticism—whether overt or subclinical, has been linked to altered lipid metabolism, calcium-phosphorus imbalance, and hepatobiliary dysfunction, all of which may converge to promote conditions favoring CaOx urolith formation (Peterson et al. 2015; Mooney et al. 2020).

While surgical removal remains the standard of care for obstructive CaOx uroliths, recurrence is common, and medical dissolution protocols are largely ineffective (Osborne et al. 2009). Preventive strategies often emphasize dietary modification, urine dilution and recurrence monitoring. However, integrative approaches - including the targeted use of

herbal medicine -may offer additional opportunities to modulate metabolic drivers, support hepatic and adrenal function, and reduce urinary stone risk through multi-system mechanisms.

This case report describes the successful resolution of recurrent calcium oxalate urolithiasis and secondary hyperparathyroidism in a Miniature Schnauzer using individualized Western herbal formulations, dietary modification and iterative reassessment, with concurrent improvement in hepatic and metabolic parameters.

Case Description

The patient, an eight-year-old spayed female Miniature Schnauzer, was presented for integrative management of an ascending urinary tract infection (UTI) secondary to chronic calcium oxalate (CaOx) urolithiasis, in addition to a persistent hepatopathy and hypercalcemia that had shown limited improvement with conventional therapy.

She was initially evaluated for acute onset lethargy, anorexia and a single episode of vomiting. On physical examination, she was febrile with a firm, painful, distended abdomen and a newly detected cardiac murmur. Serum biochemistry revealed increased alanine aminotransferase (ALT), alkaline phosphatase (ALP), cholesterol, globulins and total calcium. Urinalysis showed bacteriuria. Survey radiographs demonstrated hepatomegaly with a mass effect, as well as mineralized calculi in the kidneys and the urinary bladder.

Referral to an internal medicine specialist was pursued. Abdominal ultrasound confirmed renal mineralization, hepatomegaly with smooth margins and homogeneous parenchyma, moderate anechoic bile with small amounts of hyperechoic material, a hyperechoic gallbladder focus without acoustic shadowing, and multiple bladder uroliths with associated debris.

Recommendations included measurement of ionized calcium, a malignancy panel, urine culture and a liver biopsy, along with supportive care. The owner declined a liver biopsy and elected to have the recommended diagnostics and supportive care provided by the primary care veterinarian.

She was hospitalized for intravenous fluids, buprenorphine analgesia, maropitant antiemetic therapy and intravenous enrofloxacin pending urine culture results. Although some improvement was observed, she remained lethargic and hyporexic, leading the owner to pursue integrative management.

Her medical history was notable for chronic urolithiasis with recurrent UTIs over several years. In July 2023, she developed urethral obstruction, and the stone was manually dislodged through the urethra via rectal palpation. In February 2024, obstruction recurred and necessitated cystotomy. Stone analysis on both occasions confirmed CaOx composition with a struvite shell. She was maintained on a prescription urinary diet formulated to reduce relative supersaturation (RSS) for CaOx, with no reported dietary indiscretion. Despite surgical removal and the prescription diet, uroliths recurred within months.

A long-standing hepatopathy had been recognized more than 18 months prior, characterized by persistent elevations in ALT and ALP. Bile acids were previously within normal limits, and prior treatment with S-adenosylmethionine and silybin (Denamarin) produced only partial improvement in liver enzyme activity.

Additional comorbidities included allergic dermatitis, suspected to be atopic in origin, which responded to Lokivetmab (Cytopoint) injections, and bilateral conjunctivitis with intermittent discharge over the preceding two months. She was receiving a joint supplement later found to contain ascorbic acid (an oxalate precursor) and cranberry (*Vaccinium macrocarpa*, a high-oxalate botanical), both undesirable in patients with CaOx urolithiasis. Other treatments included intermittent cetirizine for allergies, a probiotic and occasional topical ophthalmic therapy. Hydrochlorothiazide

had been prescribed after cystotomy but had been discontinued.

At the initial integrative consultation, physical examination revealed a quiet, timid and lethargic patient. Body condition score was 7/9 with a muscle condition score of 2.5/3. The ears and distal limbs were cool to the touch, while the ventrum and face were warm. Abdominal palpation elicited retroperitoneal pain and the liver was palpably enlarged. A grade II/VI systolic murmur was auscultated. Mucous membranes were light pink with mild tackiness, and the tongue was wide with lateral fasciculations. Mild ventral erythema and seborrhea were noted, and a recessed vulva contained smegma within the folds.

Diagnostic evaluation confirmed persistent hepatopathy, hypercalcemia and methicillin-resistant Staphylococcus pseudintermedius bacteriuria susceptible to enrofloxacin. Abdominal imaging findings aligned with prior reports. Ionized calcium and parathyroid hormone (PTH) testing supported a diagnosis of secondary hyperparathyroidism (SHPT). Renal chemistry parameters and 25-hydroxyvitamin D levels were within normal limits, ruling out renal disease as a cause for SHPT. An adrenal evaluation including a low-dose dexamethasone suppression (LDDS) test and urine cortisol:creatinine ratio was also within normal limits, ruling out hyperadrenocorticism as a cause for SHPT. Diagnostics are summarized in Tables 1-6.

Holistic Assessment

Despite negative results on conventional testing for hyperadrenocorticism (Table 2), cortisol excess was still considered the most plausible underlying driver of this patient's multi-system presentation. This suspicion was supported by the combination of secondary hyperparathyroidism, recurrent calcium oxalate urolithiasis and persistent hepatopathy - a pattern consistent with cortisol's known effects on calcium metabolism, bone resorption, urinary chemistry and hepatic function (Ramsey et al. 2005; Mooney et al. 2020).

This scenario aligns with the concept of occult or atypical hyperadrenocorticism, in which patients exhibit clinical and biochemical signs of cortisol excess despite negative results on routine endocrine screening (Behrend 2013; Park et al. 2021). Chronic, low-grade cortisol elevation can result from genetic predisposition, recurrent inflammation or infection, immune dysregulation, environmental stress or cumulative metabolic strain. Over time, this state contributes to endocrine imbalance, impairs renal calcium and mineral handling, elevates parathyroid hormone, reduces hepatic clearance, promotes vacuolar hepatopathy and increases susceptibility to urinary tract urolithiasis (Mooney et al. 2020; Ramsey et al. 2005).

Miniature Schnauzers are further predisposed to calcium oxalate uroliths, likely due to inherited differences in urinary concentration and mineral handling (Lekcharoensuk et al. 2000; Lulich et al. 1999). Taken together, the most coherent explanation for this case is a chronic, subclinical cortisol excess that destabilized metabolic homeostasis in a genetically primed patient. This framework shaped the integrative treatment plan, prioritizing adrenal modulation, inflammation control, mineral balance restoration, and hepatic and urinary tract support (Watson 2016).

Integrative Therapeutic Approach

At the initial integrative consultation, the primary goals were to support resolution of the methicillin-resistant *Staphylococcus pseudintermedius* urinary tract infection, reduce lower urinary tract inflammation and stabilize hepatic function during antimicrobial therapy. An individualized Western herbal prescription was initiated containing *Astragalus membranaceus,*

Bupleurum falcatum, Taraxacum officinale (leaf), *Glycyrrhiza glabra, Althaea officinalis* (root), and *Silybum marianum* (see Table A for composition, extract ratios, dosing and actions; *Althaea officinalis* (root) was dispensed separately as a glycetract, see Table F). This formulation was intended to enhance immune competence and vitality (*Astragalus membranaceus*), reduce hepatic congestion and support bile flow (*Bupleurum falcatum, Taraxacum officinale leaf*), buffer and soothe the urinary mucosa (*Althaea officinalis* root), provide hepatoprotection and antioxidant support (*Silybum marianum*), and gently modulate stress physiology while improving palatability (*Glycyrrhiza glabra*).

Following this course, the formula was revised to emphasize urinary antilithic support and gentle diuresis, while maintaining hepatic and systemic tone. The second prescription included *Astragalus membranaceus, Taraxacum officinale* (leaf), and *Silybum marianum*, with the addition of *Zea mays* and *Crataeva nurvala* (see Table B). This combination was selected to promote diuresis and mucosal soothing (*Taraxacum officinale* leaf, *Zea mays*), improve bladder tone and provide anti-urolithic activity (*Crataeva nurvala, Taraxacum officinale* leaf), maintain hepatoprotection (*Silybum marianum*), and provide ongoing adaptogenic and immune support (*Astragalus membranaceus*). For palatability, a small proportion of *Glycyrrhiza glabra* was temporarily added with a compensatory reduction in *Zea mays*, though *Glycyrrhiza glabra* was later removed as the protocol evolved (see Table C).

When secondary hyperparathyroidism was confirmed, with ionized calcium at the upper end of normal and normal renal and vitamin D status, the protocol was adjusted to address suspected adrenal dysregulation and support renal–hepatic physiology. The third formula contained *Astragalus membranaceus, Taraxacum officinale* (leaf), *Silybum marianum*, *Crataeva nurvala*, and *Rehmannia glutinosa* (see Table D). *Rehmannia glutinosa* was introduced for its adrenotrophorestorative and nephro-hepatoprotective actions, while *Glycyrrhiza glabra* was omitted at this stage due to concerns that glycyrrhizin may influence PTH dynamics (Armanini et al. 2006). Later on, the diet was transitioned from a prescription urinary kibble to a commercial fresh food diet with CaOx RSS <14.

After the diet change, marked hypertriglyceridemia and rising liver enzymes developed. The herbal plan was adjusted again, prioritizing lipotropic and bile-flow support while maintaining urinary protection. The final formula included *Astragalus membranaceus*, *Crataeva nurvala*, *Rehmannia glutinosa*, *Taraxacum officinale* (root) and *Cynara scolymus* (see Table E). Ursodeoxycholic acid (62.5 mg PO BID) was added to improve bile flow and reduce cholestatic injury, and the diet was reformulated into a lower-fat RSS-compliant fresh food plan. *Dioscorea villosa* was dispensed for as-needed use to address transient biliary spasm and discomfort following initiation of ursodeoxycholic acid.

Monitoring and Outcome

Within 72 hours of initiating the first herbal formula (Table A), the patient demonstrated rapid clinical stabilization. At the initial recheck, clinical signs of urinary tract infection had resolved and urine culture confirmed sterility. Serum chemistry, however, continued to show elevated liver enzymes and secondary hyperparathyroidism (SHPT) was documented with elevated PTH, high-normal ionized calcium and normal vitamin D status. Diagnostic imaging at this stage revealed persistent bladder

calculi and mineralization of the left renal pelvis.

Because uroliths persisted, the herbal formula was adjusted to emphasize urinary antilithic and diuretic actions while maintaining hepatic support (Table B/C). Over the following weeks, the patient remained comfortable, and repeated radiographs confirmed clearance of the bladder stones, while renal pelvic mineralization persisted but remained stable. Stone resolution coincided with durable elimination of recurrent UTIs, marking a significant clinical turning point.

Despite negative UCCR and LDDS results, an occult endocrine driver remained strongly suspected as the cause of SHPT - most consistent with occult hyperadrenocorticism. The rationale was that SHPT developed in the absence of renal dysfunction or vitamin D deficiency, indicating endocrine dysregulation. The herbal formula was therefore revised to support adrenal balance, renal protection and hepatic function (Table D). After several weeks on this protocol, PTH values normalized, ionized calcium remained stable and SHPT fully resolved. This outcome was particularly significant, as it demonstrated correction of a suspected underlying pathophysiologic driver rather than transient management of downstream effects.

Once the patient was clinically stable and free of bladder calculi, the diet was transitioned from a prescription urinary kibble to a fresh food to improve palatability, nutrient bioavailability and metabolic support while maintaining calcium oxalate RSS compliance (RSS <14). Liver enzymes initially improved, but subsequent monitoring revealed marked hypertriglyceridemia together with rebound increases in ALT, ALP and GGT. Ultrasound was repeated at this stage and showed mildly rounded hepatic margins with hyperechoic parenchyma and small nodules, consistent with vacuolar/endocrine hepatopathy. The gallbladder contained moderate dependent debris and small partially shadowing calculi, though the wall and biliary tree remained normal. Importantly, the urinary bladder remained free of calculi.

To address these changes, the herbal protocol was adjusted to include herbs with lipotropic and choleretic actions (Table E). The diet was also modified to a lower-fat, RSS-compliant fresh food plan and Ursodeoxycholic acid was added to improve bile flow and hepatobiliary function. Transient biliary discomfort occurred after ursodiol initiation but resolved with as-needed *Dioscorea villosa* (Table F).

Over subsequent weeks of monitoring, the patient's biochemical parameters demonstrated sustained improvement. ALT trended downward (459 → 195 U/L), ALP fluctuated but stabilized below prior peaks and cholesterol steadily declined. Repeat imaging confirmed ongoing absence of bladder and urethral stones, stable renal pelvic mineralization and no evidence of biliary obstruction. The patient maintained excellent appetite, comfort and quality of life. Collectively, these findings highlight not only resolution of acute disease processes but also correction of SHPT, stabilization of hepatopathy and prevention of calcium oxalate recurrence under integrative management (see Tables 1-6 for serial biochemical and imaging data).

Discussion

This case highlights how a targeted, multi-phased herbal protocol can address interconnected endocrine, metabolic and urinary tract disturbances in a genetically predisposed breed. Miniature Schnauzers are recognized for recurrent calcium oxalate urolithiasis, vacuolar hepatopathy and idiopathic hyperlipidemia, conditions historically managed as separate disorders (Xenoulis & Steiner 2010; Watson 2016). Emerging evidence, however, supports a unifying model in which chronic cortisol excess - whether overt or occult - drives hyperlipidemia, oxidative stress and calcium-phosphorus imbalance, creating a metabolic environment that predisposes to both vacuolar hepatopathy and calcium oxalate urolithiasis (Ramsey et al. 2005; Mooney et al. 2020). Although hyperlipidemia initially improved with dietary modification, its rebound following the diet change suggests an underlying endocrine driver rather than diet alone, consistent with reports linking cortisol dysregulation to altered lipid metabolism in predisposed breeds. Standard endocrine tests may fail to detect cortisol excess due to episodic hormone secretion, early or atypical disease states, adrenal enzyme heterogeneity and assay sensitivity limitations, all of which can yield false-negative results despite clinically significant hypercortisolism. While each step in this cascade is individually documented, this case provides clinical evidence of the entire sequence operating in a genetically susceptible patient.

Within this framework, *Astragalus membranaceus* was included in all formulations for its immunomodulatory, adaptogenic, hepatoprotective and renoprotective actions. Experimental studies demonstrate that *Astragalus membranaceus* polysaccharides enhance macrophage activity, modulate cytokine balance, reduce oxidative stress and protect hepatic and renal tissues from metabolic and toxin-induced injury (Liu et al. 2004; Pan et al. 2014). These findings parallel its traditional veterinary use in chronic infection, renal disease and immune dysregulation (Wynn & Fougère 2007).

Supporting herbs such as *Silybum marianum* and *Bupleurum falcatum* provided well-documented hepatoprotective and antioxidant effects during the initial phase. *Bupleurum falcatum*, rich in *saikosaponins*, has demonstrated anti-inflammatory and hepatoprotective properties in hepatic injury models, reducing enzyme leakage and preserving tissue architecture (Yamamoto et al. 2000). *Silybum marianum*, via silymarin-mediated membrane stabilization, free-radical scavenging and anti-inflammatory activity, is similarly supported by experimental and clinical studies (Flora et al. 1998). These agents were employed early to reduce hepatic burden during antimicrobial therapy and initial metabolic stabilization. In parallel, *Althaea officinalis* and *Zea mays* contributed demulcent and mild diuretic effects, protecting urinary tract mucosa and promoting comfort during infection resolution (Blumenthal et al. 2000).

As recurrent urolithiasis emerged as the primary concern, *Crataeva nurvala* was incorporated for its anti-urolithic and bladder-tonic properties, supported by both experimental and clinical data demonstrating improved bladder tone and reduced recurrence risk (Mishra et al. 2010). *Taraxacum officinale* served dual roles depending on plant part: the leaf provided diuresis, while the root supported bile metabolism and lipid clearance, consistent with reported cholagogue and hepatic effects (Clare et al. 2009; Hu & Kitts 2005).

When secondary hyperparathyroidism was confirmed, *Rehmannia glutinosa* was added for its adrenotrophorestorative and nephroprotective properties. Pharmacologic studies have demonstrated that *Rehmannia glutinosa* extracts modulate HPA axis function, suppress parathyroid hormone secretion, restore calcium–phosphorus balance, and protect against corticosteroid-induced hepatic and renal injury (Chen et al. 2012; Gao et al. 2013). Clinical resolution of secondary hyperparathyroidism after its introduction in this case aligns with these reported mechanisms.

As hyperlipidemia and cholestatic changes became apparent, *Cynara scolymus* was included for its choleretic, antioxidant and lipid-lowering effects, supported by both experimental and clinical research (Rondanelli et al. 2013). Combined with dietary fat reduction and ursodeoxycholic acid, this phase targeted hepatic lipid accumulation, bile flow and metabolic inflammation, completing a multi-phased approach aimed at endocrine, metabolic and urinary tract stability.

Conclusion

This case demonstrates the successful resolution of secondary hyperparathyroidism and recurrent calcium oxalate urolithiasis in a Miniature Schnauzer through an individualized, multi-phased Western herbal medicine protocol. By addressing suspected occult hyperadrenocorticism as an upstream driver of hyperlipidemia, oxidative stress, calcium dysregulation and hepatopathy, the therapeutic

approach not only eliminated infection, stones, and endocrine imbalance, but also prevented recurrence—outcomes rarely reported when the underlying cause of SHPT remains undefined.

Findings from this case align with emerging evidence linking cortisol excess, hyperlipidemia, oxidative stress, calcium-phosphorus imbalance and hepatobiliary dysfunction as interconnected elements of a broader metabolic-endocrine disturbance. While occult hyperadrenocorticism remains difficult to confirm with standard diagnostics, the clinical improvement seen here supports its role as a plausible upstream driver influencing hyperparathyroidism and hyperlipidemia, and downstream calcium oxalate formation.

By employing Western herbal medicine with adaptogenic, hepatoprotective, antilithic and endocrine-modulating actions alongside dietary optimization, it was possible to achieve sustained metabolic and clinical remission. This case highlights the potential for integrative veterinary medicine to address complex, multi-system disorders through individualized, evidence-based protocols.

Prospective studies evaluating the relationship between chronic cortisol excess, hyperlipidemia and calcium oxalate recurrence are warranted to clarify causality and guide future integrative treatment strategies. Limitations of this case report include the absence of definitive diagnostic markers for occult hyperadrenocorticism and the challenges to attribute outcomes to individual interventions within a multimodal strategy. Nonetheless, these findings support further investigation into endocrine-metabolic pathways underlying recurrent urolithiasis and hepatopathy, as well as the role of veterinary Western herbal medicine in modulating these processes.

Conflicts of Interest

The patient's owner is related to an employee at the author's medical center. The author had no role in treatment administration and declares no conflicts of interest.

Appendix and Tables

Serial Blood and Urine Monitoring: (Relevant values provided. Full diagnostic results available upon request.)

Table 1: Parathyroid and Calcium Evaluation

Time Period	Ionized Calcium (1.24-1.43 mmol/L)	Parathyroid Hormone (1.10-10.60 pmol/L)	Parathormone Related Protein (0.0-1.0 pmol/L)	25-Hydroxyvitamin D (112-366 nmol/L)
Initial Presentation (Pre-integrative care)	1.39 mmol	29.90 pmol/L	0	277
4 month recheck (On herbal formula in Table D)	1.40 mmol/L	1.00 pmol/L	0	-
8 month recheck (On herbal formula in Table E)	1.35 mmol/L	-	-	-

Table 2: Adrenal and Renal Evaluation (initial presentation)

Low Dose Dexamethasone Suppression Test (LDDS) to assess Cortisol (1.0-5.0 µg/dl)	Urine Cortisol/ Creatinine Ratio (<=26)	Blood Urea Nitrogen (9.0-29.0 mg/dL) Creatinine (0.4-1.4 mg/dL) SDMA (<14.0 UG/dL)
Pre-Dexamethasone Cortisol: 2.4 µg/dl 4-Hours Post-Dexamethasone Cortisol: 0.6 µg/dl 8-Hours Post-Dexamethasone Cortisol: 0.5 µg/dl	13	BUN 24.8 mg/dL Creatinine 1.0 mg/dL SDMA 7.6 UG/dL

Table 3: Urine Evaluation

Time Period	Urinalysis	Urine Culture
Initial Presentation	Specific Gravity 1.034 (1.015-1.050) pH 7.0 (5.5-7.0) WBC 11-20 (0-3 HPF) RBC 4-10 (0-3 HPF) Bacteria Cocci 10-25 HPF (0 HPF)	Meth-Resist *Staph pseudintermedius*
1 month recheck	Specific Gravity 1.022 (1.015-1.050) pH 5.5 (5.5-7.0) WBC 2-3 (0-3 HPF) RBC 0-1 (0-3 HPF) Bacteria NONE	No Growth
7 month recheck	Specific Gravity 1.022 (1.015-1.050) pH 8.5 (5.5-7.0) WBC NONE (0-3 HPF) RBC NONE (0-3 HPF) Bacteria NONE	No Growth

Table 4: Hepatic Evaluation

Time Period	ALT (0-120 U/l)	ALP (0-140 U/l)	GGT (0-14 U/l)	Cholesterol (120-310 mg/dl)	Triglycerides (29-291 mg/dL)
Initial Presentation (Pre-integrative care)	238 U/l	517 U/l	10 U/l	337 mg/dl	-
1 month recheck (On Herbal Formula in Table A)	303 U/l	730 U/l	12 U/l	388 mg/dl	-
2 month recheck (On Herbal Formula in Table B)	196 U/l	325 U/l	15 U/l	277 mg/dl	-
3 month recheck (On Herbal Formula in Table B/C)	179 U/l	285 U/l	15 U/l	286 mg/dl	-
4 month recheck (On Herbal Formula in Table D) *Fresh Food Diet	459 U/l	389 U/l	15 U/l	364 mg/dl	-
5 month recheck (On Herbal Formula in Table D)	372 U/l	452 U/l	14 U/l	336 mg/dl	618 mg/dL
6 month recheck (On Herbal Formula in Table E)	341 U/l	253 U/l	<10 U/l	304 mg/dl	-
7 month recheck (On Herbal Formula in Table E) *Fresh Food Diet Amended to Lower Fat	382 U/l	636 U/l	21 U/l	>450 mg/dl	-
8 month recheck (On Herbal Formula in Table E)	284 U/l	710 U/l	15 U/l	420 mg/dl	-
9 month recheck (On Herbal Formula in Table E) *As of this writing	195 U/l	698 U/l	<10 U/l	352 mg/dl	-

Diagnostic Imaging

Table 5: Ultrasonography

Initial Presentation (Pre-integrative care)	The liver was mildly enlarged in size with smooth margins and homogenous parenchyma. The gallbladder was normal and contained a moderate amount of anechoic bile and a small amount of hyperechoic bile. There was a hyperechoic round area which did not shadow. The cystic bile duct was not distended. The left kidney had smooth margins with normal corticomedullary definition and no renal pelvis dilation. Mineralization was noted in the renal pelvis. The urinary bladder contained a large amount of debris and stones. The remaining structures were reported as unremarkable (reported by North Georgia Veterinary Specialists).
Recheck after 7 months of Integrative Treatment	The liver had mildly rounded margins with a hyperechoic echotexture with some small nodules throughout. The gallbladder contained moderate dependent debris and some partially shadowing calculi. The gallbladder wall was normal. The biliary tree was normal. The spleen had a few poorly defined hypoechoic nodules embedded within the parenchyma, and mildly rounded margins in some areas. There was a large stone in the left renal pelvis, and reduced corticomedullary definition with mineralization. The urinary bladder was mildly distended with urine, and there were no calculi present. The remaining structures were reported as unremarkable (reported by Insight Veterinary Ultrasonography).

Table 6: Radiographic Assessment of Urinary Tract

Initial Presentation (Pre-integrative care)	Radiopaque mineralization of left renal pelvis. Approx. ten radiopaque uroliths present in urinary bladder ranging from 4.1 mm to 6.73 mm and associated radiopaque urinary debris.
2 month recheck (Herbal Formula Table B)	Radiopaque mineralization of left renal pelvis unchanged. No obvious radiopaque calculi in urinary bladder or urethra.
3 month recheck (Herbal Formula Table B/C)	Radiopaque mineralization of left renal pelvis unchanged. No obvious radiopaque calculi in urinary bladder or urethra.
6 month recheck (Herbal Formula Table E)	Radiopaque mineralization of left renal pelvis unchanged. No obvious radiopaque calculi in urinary bladder or urethra.
8 month recheck (Herbal Formula Table E)	Radiopaque mineralization of left renal pelvis unchanged. No obvious radiopaque calculi in urinary bladder or urethra.

Herbal Formulas: (Information derived from Wynn & Fougère, 2007, and CIVT GDVWHM course notes.)

Table A: Initial Formula (based on approx. 1ml/5kg BID dosing for a 7.5 kg patient)

Herb (Latin binomial) and Concentration	Proportion of Total Formula	Total Daily Dose	Herbal Actions	Herbal Indications	Herbal Energetics
Astragalus (*Astragalus membranaceus*) 1:2	30%	0.7 ml (350mg dried herb)	Immune enhancing, tonic, adaptogen, renoprotective, hepatoprotective, cardiotonic, diuretic, and hypotensive	Indicated for chronic infection, early heart failure, immune deficiency, renal disease, chronic hepatitis, hypertension, chronic debility, aging, and an adjunct to cancer treatment.	Sweet and slightly warm
Bupleurum (*Bupleurum falcatum*) 1:2	20%	0.5 ml (250mg dried herb)	Anti-inflammatory, analgesic, antipyretic, diaphoretic, carminative, hepatoprotective, mild sedative, and alterative	Indicated in this case for the aforementioned actions, and indicated for liver disease, chronic hepatitis, emotional swings, certain forms of depression, and minor nervous tension.	Bitter, cool, and slightly acrid
Dandelion Leaf (*Taraxacum officinalis*) 1:2	20%	0.5 ml (250mg dried herb)	Diuretic and cholagogue	Indicated for these actions and for adjunct management of urinary calculi.	Bitter, cold and dry
Licorice Root (*Glycyrrhiza gabra*) 1:1	10%	0.2 ml (200mg dried herb)	Anti-inflammatory, adaptogen, antispasmodic, laxative, estrogenic, anti-ulcerogenic, expectorant, and adrenal restorative	Primarily selected as a flavor enhancer. Also indicated for atopic dermatitis, Addison's disease, adrenal insufficiency, to augment corticosteroid use and aid in withdrawal, inflammatory conditions, rheumatoid arthritis, urinary tract inflammation, gastric ulcers, bronchitis and cough.	Sweet and neutral
Milk Thistle (*Silybum marianum*) 1:1	20%	0.5 ml (500mg dried herb)	Hepatoprotective, demulcent, cholagogue, and antioxidant	It is indicated for hepatitis, cholangiohepatitis, renoprotective, toxic injury to liver, pancreatic protection, hyperlipidemia.	Bitter and warm

Dispensed as: Initially, given 0.5 ml by mouth twice daily for five days. Then, 1.2 ml twice daily to reach the total daily dose as described above. Given for four weeks.

Table B: Urolith Targeted Formula (based on approx. 1ml/5kg BID dosing for a 7.7 kg patient)

Herb (Latin binomial) and Concentration	Proportion of Total Formula	Total Daily Dose	Herbal Actions	Herbal Indications	Herbal Energetics
Astragalus (*Astragalus membranaceus*) 1:2	20%	0.6 ml (300mg dried herb)	As above	As above	As above
Dandelion Leaf (*Taraxacum officinalis*) 1:2	20%	0.6 ml (300mg dried herb)	As above	As above	As above
Milk Thistle (*Silybum marianum*) 1:1	20%	0.6 ml (600mg dried herb)	As above	As above	As above
Corn Silk (*Zea mays*) 1:2	20%	0.6 ml (300mg dried herb)	Mild diuretic, urinary demulcent, tonic and antilithic	Indicated for acute and chronic inflammation of the urinary tract, cystitis and prostatitis. In TCM, uses and properties include edema, hepatitis, nephratitis, cholelithiasis, jaundice, and hypertension.	Sweet, cool, and draining.
Crataeva (*Crataeva nurvala*) 1:1	20%	0.6 ml (600mg dried herb)	Anti-urolithic, antimicrobial, tonic and anti-inflammatory on the urinary tract	Indicated for chronic UTIs, neurogenic (hypotonic and atonic bladder) incontinence, calcium oxalate urolithiasis, and prevention of recurrent bladder stone.	Neutral and cooling

Dispensed as: Initially, given 0.5 ml by mouth twice daily for five days. Then, 1.5 ml twice daily to reach the total daily dose as described above. Given for three weeks.

Table C: Urolith Targeted Formula—Amended for palatability (based on approx. 1ml/5kg BID dosing for a 7.7 kg patient)

Herb (Latin binomial) and Concentration	Proportion of Total Formula	Total Daily Dose	Herbal Actions	Herbal Indications	Herbal Energetics
Astragalus (*Astragalus membranaceus*) 1:2	20%	0.6 ml (300mg dried herb)	As above	As above	As above
Dandelion Leaf (*Taraxacum officinalis*) 1:2	20%	0.6 ml (300mg dried herb)	As above	As above	As above
Milk Thistle (*Silybum marianum*) 1:1	20%	0.6 ml (600mg dried herb)	As above	As above	As above
Corn Silk (*Zea mays*) 1:2	15%	0.45 ml (225mg dried herb)	As above	As above	As above
Crataeva (*Crataeva nurvala*) 1:1	20%	0.6 ml (600mg dried herb)	As above	As above	As above
Licorice Root (*Glycyrrhiza gabra*) 1:1	5%	0.15 ml (150mg dried herb)	As above	As above; included as a flavor enhancer for palatability	As above

Dispensed as: Initially, given 0.5 ml by mouth twice daily for three days. Then, 1.5 ml twice daily to reach the total daily dose as described above. Given for four weeks.

Table D: SHPT Targeted Formula (based on approx. 1ml/5kg BID dosing for a 7.7 kg patient)

Herb (Latin binomial) and Concentration	Proportion of Total Formula	Total Daily Dose	Herbal Actions	Herbal Indications	Herbal Energetics
Astragalus (*Astragalus membranaceus*) 1:2	20%	0.6 ml (300mg dried herb)	As above	As above	As above
Dandelion Leaf (*Taraxacum officinalis*) 1:2	20%	0.6 ml (300mg dried herb)	As above	As above	As above
Milk Thistle (*Silybum marianum*) 1:1	20%	0.6 ml (600mg dried herb)	As above	As above	As above
Crataeva (*Crataeva nurvala)* 1:1	20%	0.6 ml (600mg dried herb)	As above	As above	As above
Rehmannia (*Rehmannia glutinosa*) 1:2	20%	0.6 ml (300mg dried herb)	Adrenotrophorestorative antioxidant, aperient, bitter tonic, anti-inflammatory, hepatoprotective and diuretic.	Indicated for adrenal disease, atopic dermatitis and other dry inflammatory skin diseases, kidney disease, diabetes mellitus, rheumatoid arthritis, asthma, urticaria, and chronic nephritis.	Sweet, slightly bitter, cold.

Dispensed as: Initially, given 0.5 ml by mouth twice daily for three days. Then, 1.5 ml twice daily to reach the total daily dose as described above. Given for four weeks.

Table E: SHPT Targeted Formula—Amended for hyperlipidemia (based on approx. 1ml/5kg BID dosing for a 7.7 kg patient)

Herb (Latin binomial) and Concentration	Proportion of Total Formula	Total Daily Dose	Herbal Actions	Herbal Indications	Herbal Energetics
Astragalus (*Astragalus membranaceus*) 1:2	20%	0.6 ml (300mg dried herb)	As above	As above	As above
Crataeva (*Crataeva nurvala*) 1:1	20%	0.6 ml (600mg dried herb)	As above	As above	As above
Rehmannia (*Rehmannia glutinosa*) 1:2	20%	0.6 ml (300mg dried herb)	As above	As above	As above
Dandelion Root (*Taraxacum officinalis*) 1:2	20%	0.6 ml (300mg dried herb)	Laxative and cholagogue	Indicated as a digestive tonic and a liver tonic	Bitter, cold and dry
Globe Artichoke (*Cynara scolymus*) 1:2	20%	0.6 ml (300mg dried herb)	Bitter tonic, antiemetic, diuretic, choleretic and hepatoprotective	Indicated for hyperlipidemia, cholestatic, other liver diseases, nausea, constipation, flatulence, hepatoprotective, bitter, and a hepatic trophorestorative. Traditionally, it has also been used as a depurative, for rheumatism, arthritis, and gout.	Slightly, bitter, cooling, salty, moist but sweet

Dispensed as: Initially, given 0.5 ml by mouth twice daily for three days. Then, 1.5 ml twice daily to reach the total daily dose as described above. Giving currently as of this writing.

Table F: Herbs dispensed as singles and given as needed:

Herb (Latin binomial) and Concentration	Dose	Herbal Actions	Herbal Indications	Herbal Energetics
Marshmallow Root (*Althaea officinalis*) 1:5	0.5 ml (100 mg dried herb) every 12 hours for the initial 4 weeks. Then, as needed	Demulcent, vulnerary, diuretic and nutritive.	Indicated for digestive issues, especially gastroenteritis, gastric ulcer, colitis and diarrhea and for urinary tract inflammation (cystitis, nephritis, urethritis).	It is sweet, bitter and cool
Wild Yam (*Dioscorea villosa*) 1:4	0.5 ml (125 mg dried herb) every 12 hours as needed.	Spasmolytic, anti inflammatory, anti rheumatic and estrogen-modulating.	Indicated for abdominal spasms or irritation including that associated with cholecystitis, tenesmus, painful colitis, inflammatory bowel disease, flatulent colic, dysmenorrheal symptoms, menstrual pain, hyperlipidemia.	Bitter, mildly pungent and sour

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CASE REPORT

The Use of Acupuncture and Chinese Herbal Medicine in the Management of a Geriatric Mare

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Abstract

A 32 year old retired mare with a Kidney Yin and Qi deficiency was managed using a combination of acupuncture and Chinese herbal medicine to improve quality of life. She was presented with stiffness in her hind legs, chronic arthritis and loss of muscle mass. Concurrent medications included Firocoxib. Acupuncture treatment focused on tonifying Kidney Yin and Qi and Chinese herbal medicine was used to further tonify Kidney Yin. The mare responded well to management, allowing for improvement in quality of life with reducing doses of Firocoxib. This case shows the cumulative benefit of adding acupuncture and herbal medicine into the overall management of geriatric patients.

History

A 32 year old retired Sport horse mare was presented in late autumn for alternative therapies to keep her comfortable throughout winter. She was a geriatric mare who has performed at medium-level competitions (evented at 2* level with her current owner). She was retired in 2017 following significant injury to both front check ligaments. She recovered well from this injury and has not had any further complications. She was presumed to have osteoarthritis two years ago and started on Firocoxib (0.15 mg/kg once daily (SID)) in feed to keep her 'paddock sound'. She received a moderate amount of feed daily (a mix of fibre and grain based feeds) with added supplements to help her maintain body condition and ad lib pasture and hay.

Clinical Signs and Western Diagnosis

The mare had a body condition score of 4/9 with adequate fat coverage but lacking muscle mass, most noticeable along the epaxial muscles ('topline') and gluteal muscles. She also had a moderately swayed back. A lameness evaluation revealed mild bilateral hindlimb lameness with positive proximal limb flexion tests. For a 32 year old horse, the mare moved much more freely than initially expected. The right fore foot showed increased weight-bearing on the lateral aspect. The mare also showed noticeable tension in the epaxial muscles along the lumbar spine. These findings indicate chronic pain with subsequently reduced quality of life.

This mare has presumed osteoarthritis in her hocks. This diagnosis was initially made by another veterinarian and was supported by her history and lameness evaluation findings. Radiographs were not taken as clinical signs and response to treatment were found to be the most reliable indicator for osteoarthritis in horses (Byam-Cook & Singer 2009; Yvonne et al. 2012). Tarso-metatarsal (TMT) and distal-intertarsal (DIT) joint arthritis is common in horses, with an increased prevalence shown following loading of the joints in ridden work (McIlwraith, Frisbie & Kawcak 2012; Tranquille et al. 2011). Her comfort is currently well-managed through the use of Firocoxib.

Clinical Signs and Traditional Chinese Medicine (TCM) Diagnosis

This mare, despite being 32 years old, was rather sprightly. There are moments where she will trot around her paddock with her ears pricked forward

seemingly enjoying herself. There are, however, other days where she moves through the paddock slower and at times appears weak in her hind end. Her coat was a little dry but otherwise of good quality. There was no evidence of underlying skin disease at time of examination, although the owner reports the mare to be prone to superficial dermatitis in the winter months. She had a few grey hairs coming through, most noticeably on the top of her rump and at the base of her ears. Her appetite was good and she ate at a slow but steady pace. She defaecated an appropriate amount, however, the faeces were reported to be dry at times. She was previously diagnosed with chronic atrial fibrillation.

The mare grazed in a paddock alone, although has previously enjoyed the company of other horses and seemed to thrive in a herd environment. She was people-focused and used to enjoy competing. The mare was competitive in her day, this in part led her to being injured as she did not slow down from pain. The mare is a Wood / Liver personality type. She had a tendency to run warm rather than cold and her symptoms were reported to worsen over the winter months. As mentioned above, she showed lack of muscle mass and tension along the epaxial muscles.

At the time of the initial examination, the mare's pulse was difficult to find, slightly fast, deep, easily compressible and lacking tone. Her tongue was a dark pink colour and dry. On palpation of the channels, she showed mild sensitivity along the Bladder channel from BL 13 to BL 25. On deeper palpation, BL 23 stood out as an active point whereas the remaining Bladder channel points became less reactive. The Kidney ting point (KI 1) palpated deficient. GB 29 palpated as an active point indicating upper hindlimb pain.

The mare was diagnosed with a Kidney Yin and Qi deficiency. The tongue was indicative of a Yin deficiency and the pulse related to both a Yin and Qi deficiency. The Kidney association point (BL 23) was reactive. This is also supported by the mare's personality type of Wood as Wood drains Water in the reduction cycle (Twicken 2012).

Conventional Treatment

The mare has been on Firocoxib in feed at a dose of 0.15 mg/kg once daily. This is higher than the recommended dose of 0.1 mg/kg SID (Equine Drugs - Veterinary Advances 2021). Following assessment of the mare and the addition of TCM treatments, the dose of Firocoxib was reduced to 0.1 mg/kg in feed SID. Further reductions in the dose (to 0.1mg/kg in feed every second day) were to be made pending the response to further TCM treatments.

TCM Treatment

The TCM treatment goal was to tonify both Kidney Yin and Kidney Qi. Seirin acupuncture needles of varying sizes were used during treatment. These included Seirin J-type 0.30 x 50mm needles (used for acupuncture points in large muscle bellies, such as the Shen-points in the gluteal muscles), Seirin J-type 0.30 x 40mm needles (used for acupuncture points on the torso and proximal limbs) and Seirin D-type 0.35 x 15mm (used for superficial acupuncture points on the distal limbs).

Acupuncture treatment was started at Bai Hui. From here, the kidneys were tonified by needling KI 1, BL 23, KI 3, and the combination of Shen-Shu, Shen-Peng and Shen-Jiao. For further pain relief; BL 60 and GB 29 were needled. Further detail on the acupuncture points used is outlined in Appendix 1. Electroacupuncture (EA) was added connecting BL 23 to GB 29 and BL 60 to KI 3 bilaterally. The frequency was set to a tonifying frequency of 10 Hz and intensity at 2 mA. This was left on for 20 minutes. The needles that were not stimulated by EA were tonified by clockwise rotation with emphasis on insertion and were left in for ten minutes (Yoon, Lee and Chae 2022). Following treatment, the mare's pulse improved. The pulse became easier to find, less compressible and its tone normalised.

First Follow Up Treatment

At the first follow up treatment four weeks later, the mare was described as being happier, brighter and moving around more. She had also improved in body condition. Her pulse remained difficult to find, deep and easily compressible. The pulse was less rapid at this visit. Her tongue was pink and dry

(the colour was less dark than at the previous visit). On palpation of acupuncture points, the mare was significantly less reactive to palpation along the bladder channel. BL 23 (palpating 'sticky') and GB 29 (palpating 'warm') remained as active points. The previous diagnosis of Kidney Yin and Qi deficiency remained.

No ting points were needled due to distal limbs being wet. BL 23, KI 3, BL60, Shen-Shu, Shen-Peng and Shen-Jiao were needled as last time. The needles were tonified as per previous visit. The mare became extremely reactive following attempted needling of GB 29 on the left side. Balance Method I (Twicken 2012) was used to treat GB 29. TH 15 on the right side was needled to balance GB 29 as this point palpated warm on this mare. Following needling of TH 15, the mare became sedated and remained so for the remainder of the treatment. The same Balance Method was used to treat hock lameness with the point PC 7 being needled (also based on palpation). Both the needles placed following the Balance Method Acupuncture were left in for 30 minutes (Tan 2020). Due to the positive response to acupuncture needles alone at this treatment, EA was not done.

The mare was started on the Chinese herbal formula 'Zuo Gui Wan' at a low dose of two grams daily, given in feed, for six weeks. This formula consisted of the herbs Shu Di Huang, Gou Qi Zi, Shan Zhu Yu, Gui Ban Jiao, Lu Jiao Jiao, Tu Si Zi, Chuan Niu Xi and Shan Yao. As a solely tonifying formula, used to restore Kidney Yin, it was not recommended for long-term use (Beebe 2022). Further detail on the function of the individual herbs in the formula is outlined in Appendix 2.

Second Follow Up Treatment

A second follow up treatment was undertaken four weeks later. The mare was described as moving around more in the paddock and appearing much happier in herself. She had put on muscle mass along her topline and gluteal muscles. Her pulse remained difficult to find, deep and easily compressible. Her tongue was lighter pink and a little dry. The tongue is indicative of improving Yin qualities and a remaining Qi deficiency. The mare showed no reaction to palpation of any acupuncture points. The previous diagnosis of Kidney Yin and Qi deficiency remained. However, at this time, the Qi deficiency appeared to be predominating.

No ting points were needled at this treatment. BL 23, KI 3, BL60, Shen-Shu, Shen-Peng and Shen-Jiao were needled as per previous visits. SP 6 was added to help tonify both Yin and Qi and BL 40 was added to further tonify Kidney Qi. The mare responded well to the treatment and the needles were tonified as per the previous treatments. No EA was done.

Discussion

This mare presented with age-related changes including loss of muscle mass and chronic osteoarthritis. A study done by Wagner et al. (2013), found a 42% reduction in the ribosomal protein S6 kinase (S6K1) (a key enzyme involved in protein synthesis) in the gluteus muscle of aged horses. Another study, done by Li et al. (2016), found a 40% reduction in Cytochrome-C Oxidase (CcO) activity in both the gluteus and triceps as well as lower citrate synthase levels in the triceps of ageing horses. This indicates reduced mitochondrial function and content, respectively. These mechanisms could explain the loss of muscle mass commonly seen in ageing horses (Paradis 2013). Acupuncture was found to increase S6K1 levels by up-regulating messenger ribonucleic acid (using low frequency EA) and significantly increase CcO expression (Li et al. 2016; Shen et al. 2024). Conversely, Wagner et al. (2013) showed that healthy ageing horses have similar whole-body protein kinetics when compared to mature horses. Thus, there should be no loss of muscle mass observed in horses without an underlying medical condition. In this case, the loss of muscle mass noted could be explained through the chronic pain from osteoarthritis leading to reduced movement.

This mare's comfort was managed with Firocoxib at 0.15 mg/kg PO SID. Despite the lack of disease-modifying effects, non steroidal anti-inflammatory drugs (NSAID) remain a common modality for managing the clinical symptoms seen with osteoarthritis (Doucet et al. 2008). The dose was altered to the recommended dose of 0.1 mg/kg SID (Equine Drugs - Veterinary Advances 2021). Firocoxib is a cyclooxygenase (COX) inhibitor which specifically inhibits the COX-2 isoenzyme involved in the inflammatory cascade (Frisbie & Donnell 2014). COX-2 has a minimal role in maintaining normal physiologic function of the gastrointestinal and renal systems when compared to COX-1 (Frisbie & Donnell 2014). As a result, Firocoxib shows reduced side effects when compared to Phenylbutazone as well as improved clinical outcomes including reduced local pain and improved range of motion (Doucet et al. 2008; Frisbie & Donnell 2014). At the correct dose, Firocoxib is a good choice for managing the clinical symptoms seen with osteoarthritis (Doucet et al. 2008).

In traditional Chinese medicine (TCM), the kidneys are the organ most closely associated with ageing (Li et al. 2023). Kidney Yin and Yang are the foundations of all Yin and Yang of the body. Their function is to nourish and consolidate (Yin), and stimulate and transform Qi (Yang). With ageing, kidney essence reduces and Kidney Yin and Yang are depleted, resulting in an imbalance and Kidney Qi deficiency. This is the basic pathogenesis of ageing from a TCM perspective (Chen et al. 2024). In this mare, Kidney Yin deficiency predominates, leading to inadequate nourishment and abnormal circulation of Qi and Blood. Another contributing factor leading to decline in Kidney Yin and Qi comes from the reduction cycle, where the child (in this case Wood) drains the parent (Water) (Twicken 2012). In addition to the Wood/Liver personality type, this mare's high level of work at an older age likely contributed to the unhealthy relationship of the reduction cycle. Acupuncture points were chosen for their ability to tonify Kidney Yin and Qi as well as promote movement of Qi (see Appendix 1). In addition, the herbal formula Zuo Gui Wan is a potent Yin tonifying formula. For additional benefit, these treatments were performed in winter, which is the most appropriate season to treat the kidney channel. The kidney channel, also called the foot Shao Yin, is extreme Yin and is associated with winter and the water element (Maoshing Ni 1995).

Balance Acupuncture Method I balances hand conditions with foot channels on the contralateral limb and vice versa (Twicken 2012). For this mare, the foot Shao Yang (GB) was balanced with the hand Shao Yang (TH) and the foot Jue Yin (LIV) balanced with the hand Jue Yin (PC). The contralateral side of the body was needled. The hindlimb was projected onto the contralateral forelimb in the same orientation (hip - shoulder and tarsus - carpus) and the horse palpated for warm points. This guided the needle placement. Needles placed following the Balance Method Acupuncture were left in for 30 minutes as per Dr Tan's recommendations (Tan 2020). This is based on Dr Tan's (2020) theory that one full cycle of Qi through a channel takes 29 minutes.

The use of acupuncture has been shown to be beneficial in the management of geriatric patients to help improve their quality of life (Silva et al. 2017). There was a noticeable improvement in quality of life for this mare, as observed by increase in voluntary movement and the ability to reduce the dose of long-term damaging medications. She will continue to receive regular acupuncture treatments. Further herbal support (aimed at tonifying Qi) will be added in the near future.

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Appendix 1: Details of Acupuncture Point Prescription

Acupuncture Point	Anatomical Location	Actions
Bai-Hui	'Hundred meetings' Located on the dorsal midline at the level of the lumbosacral space	Pain and arthritis in the hind quarters, caudal back or hip Relaxation of the horse prior for treatment
Shen-Shu	'Kidney Association Point' Located two Cun lateral to Bai Hui, one Cun medial to BL 26	Pain and arthritis in the hindquarters, back or hip Qi deficiency Movement of Qi in lower Jiao
Shen-Peng	'Kidney Shelf' Located two Cun cranial to Shen-shu and is medial to BL 25	Pain and arthritis in the hindquarters, back or hip Qi deficiency Movement of Qi in lower Jiao
Shen-Jiao	'Kidney Corner' Located two Cun caudal to Shen-shu and is medial to BL 27	Pain and arthritis in the hindquarters, back or hip Qi deficiency Movement of Qi in lower Jiao
SP 6	'San-Yin-Jiao 3' 'Yin Crossing' Located three Cun proximal to the medial malleolus, caudal to the tibial border, half a Cun posterior to the saphenous vein	Master point for the caudal abdomen Tonifies Yin, Qi and Blood
BL 23	'Kidney Association Point' Located at the level of the second lumbar interverte-bral space (L2 - L3), three Cun lateral to the dorsal midline	Back-Shu association point for the Kidney Tonifies Kidney Yin and Qi
BL 40	'Wei-Zhong' 'Bend Middle' Located at the midpoint of the transverse crease of the popliteal fossa	Master point for caudal back and hips Tonifies Kidney Qi
BL 60	'Kun-Lun' 'Kunlun Mountains' Located between the lateral malleolus of the tibia and the calcaneal tuber	'Aspirin point' Alleviates pain throughout the body, especially in the caudal back Improves Qi movement
KI 1	'Hou-Jiu' 'Pelvic Central Bulb Hoof' Located in the depression between the bulbs of the heel of the back hoof	Jing-Well point Tonifies Yin
KI 3	'Tai Xi' 'Great Ravine' Located between the medial malleolus of the tibia and the calcaneal tuber	Yuan-Source point Tonifies Kidney Yin and Qi Pain in back and hind end
PC 7	'Da-Ling' 'Great Mound' Located at the level of the accessory carpal bone, cranial to the flexor carpi ulnaris	Balance Method 1 for hock pain
TH 15	'Bo-Jian' 'Scapular Tip' Located in the depression on the dorsal border of the scapula at the junction of the scapula and scapular cartilage	Balance Method 1 for the point GB 29 (which was too painful to needle at the second visit)
GB 29	'Juo-Liao' ' Squatting Hole' Located in a depression midway between the wing of the ilium and greater trochanter of the femur	Pain and arthritis in the hind limb, gluteal muscles or coxofemoral joint

Reference: Huisheng Xie, Preast & Zhen Zhao 2007

Appendix 2: Zuo Gui Wan Herbal Formula Constituents

Herb	Latin/Western Name	Actions
Shu Di Huang	Rehmannia	Tonifies Kidney Yin and Jing
Gou Qi Zi	Lycium	Nourishes Liver and tonifies Kidney
Shan Zhu Yu	Cornus	Nourishes Liver and Kidney Yin; astringes Yin
Gui Ban Jiao	Plastrum testudinis	Nourishes Kidney; tonifies Yin, Yang and Jing
Lu Jiao Jiao	Colla corneus cervi	Nourishes Kidney; tonifies Yin, Yang and Jing
Tu Si Zi	Cuscuta	Tonifies Kidney Yin; strengthens the lower body; relieve sore back
Chuan Niu Xi	Cyathula	Tonifies Kidney; strengthens the lower body; relieve sore back
Shan Yao	Dioscoreae	Tonifies Kidney and Spleen; consolidates Jing

Reference: Beebe 2022

CASE REPORT

Evaluation of equine gastric mucosal coating using *Calendula officinalis L.* infused oils

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Abstract

Calendula officinalis L. (C. officinalis) is a widely studied, valuable medicinal plant with many beneficial actions (Zournatzis 2025). Compounds responsible for therapeutic biological activity include phenolic compounds, carotenoids, triterpenoids and mucilage (Pasca 2013). Beneficial actions of these compounds are diverse and include anti-inflammatory, antioxidant, vulnerary and mucosal surface protection.

This study reports the gastroscopic findings from four horses to determine the extent of gastric mucosal coating by *C.officinalis* infused in pure Omega-3 marine and flax seed oils (CO oil). Successful coating of the equine gastric mucosa by the CO may provide a plant-based supplement that could be used to provide protection of the equine gastric mucosa.

Introduction

Calendula officinalis L. (C. officinalis) is a valuable medicinal plant whose inflorescences are safely used in formulations both internally and externally (Shahane 2023). *C. officinalis* contains therapeutic compounds that provide beneficial anti-inflammatory, antioxidant, antiseptic, antibacterial, vulnerary and analgesic actions (Shahane 2023). These compounds, after extraction in water, alcohol or oil, may be included in rinses, salves and tinctures, or offered in dry powder and whole plant forms. The most abundant therapeutic compounds include phenolic compounds (flavonoids), carotenoids, triterpenoids (saponins), fatty acids and mucilage (Pasca 2013). These compounds are distributed throughout the *C.officinalis* inflorescence (Ossipov 2024). When extracting the plant compounds, the solubility of the compounds must be noted.

C. officinalis contains both free, lipophilic triterpenoids and water soluble, triterpenoid glycosides; the latter being saponins producing a foaming action and allowing mixing of lipophilic molecules (Pengelly 2021). Triterpenoids have antioxidant, anti-inflammatory and gastroprotective actions. The yellow-orange carotenoids are lipophilic with antioxidant, anti-inflammatory and wound healing actions. Flavonoids may be more soluble in ethanol, however have increased water solubility if glycosylated. They show antioxidant and wound healing actions, improve capillary vigour and have anti-inflammatory actions on mucosa (Shahane 2023).

Mucilage is a water soluble, gelatinous material composed of protein and long chain polysaccharides. Once extracted and in contact with water, mucilage forms a thick, gel-like, adhesive substance (Sabale 2014). Mucilage has been demonstrated to provide mucosal protection against gastrointestinal contents, along with anti-inflammatory, soothing actions on the digestive tract, acting as a demulcent for a protective functional barrier (Wynn 2007). A protective layer of mucilage on the digestive mucosa may provide a barrier to gastric acid (Bone 2013). In human pharmaceuticals, mucilage may be used as inert, safe and biodegradable natural excipient (drug delivery) agents, as are saponins (Taru 2022). Mucilage functionally separates the mucosal surface from the surroundings (Tosif 2021).

Development of a *C.officinalis* Nutritional Oil Supplement

For our clinics' equine clients ("participants") we have prepared a nutritional supplement consisting of a blended Omega-3 Fatty Acid supplement and flaxseed oils in which *C. officinalis* flowers have been infused. This *C. officinalis* oil (CO) is mixed with the horses feed to provide the beneficial effects of C.officinalis added to the effects of essential fatty acids (EFA) in pure marine Omega-3 and flaxseed oils. The benefits of these EFA's include reduction of inflammation, minimising tissue damage in the exercising horse, and support of immune and reproductive systems (Burron 2024); CO also produces spectacular coat quality and shine (personal communications).

Personal communication was made with participants using the CO, who had four ponies gastroscoped for routine gastric ulcer investigation. The participants reported the entire squamous and glandular mucosa in all the ponies was covered with a thick, shiny, gelatinous bright yellow coating, which could be washed away with water. This study was then developed with the aim of demonstrating if similar coating of the gastric mucosa by the same CO, could be repeated in more horses.

Equine Gastric Ulcer Syndrome (EGUS)

EGUS contains two entities: Equine Squamous Gastric Disease (ESGD) and Equine Glandular Gastric Disease (EGGD). EGUS can be a common problem in performance horses, induced by a variety of stress factors, conditions, diet and feeding protocols, medications, works schedules, travel, husbandry and environmental conditions (Vokes 2023).

Gastric Mucosa Protection by Mucilage

Gastroprotective activity against gastric ulcers and mucosal surface protection with plant mucilage has been demonstrated (Bone 2013). Protective effects against gastric mucosal lesions has also been demonstrated by saponins in *C. officinalis*, reducing lesions more effectively than the reference drug, Omeprazole (Yoshikawa 2001).

C. officinalis contains mucilage which has been investigated as a mucoadhesive agent (Sabale 2014). Formulation of Calendula mucilage based buccal tablets resulted in successful drug delivery systems to enhance absorption of poorly absorbed drugs. Bio adhesion of mucilage on epithelia has been tested on porcine buccal membranes where polysaccharides from *C. officinalis* showed superior and strong bio adhesion, with histology reporting adhesion on the apical membrane surface. This study suggested the plant mucilage may have therapeutic effects on irritated buccal membranes (Schmidgall 2000).

Flaxseed (*Linum usitatissimum*) also contains mucilage, and the oil has been shown to provide anti-ulcer activity in a rat model of ethanol-induced gastric ulcer. Results show that pretreatment of rats with flaxseed oil and flaxseed mucilage significantly reduced the number and length of gastric ulcers induced by ethanol (Dugani 2008).

Materials and Methods

C. officinalis flowers were grown on site and harvested every three days as the flavonoid content is highest three days after anthesis (Honorio 2016). Flowers were spread on drying racks in a ventilated room for approximately two weeks until totally dry. The extraction technique used was designed using both 40% alcohol and oil to attempt to maximise extraction accounting for solubility of all desired components (Balakrishna 2016), using 40% alcohol can effectively extract both water-soluble and fat-soluble compounds and acts as a natural preservative.

The *C.officinalis* infused oil (CO) was prepared, via maceration, in three steps.

Step One – Extraction in 40% Alcohol

250 gm dry *C.officinalis* flowers were rehydrated in 250 ml 40% (80 proof) alcohol (Smirnoff 40% alc/vol.) for 48 hours. The rehydrated flowers were placed in a 1000 ml oil which consisted of 50% Omega 3 pure marine oil (Kentucky Equine Research (KER) EO3) and 50% Flax Oil (Stoney Creek cold pressed Flaxseed oil). Using a hand blender, the flower/oil mix was macerated twice daily for 48 hours. The flower/oil mix was stored in a warm room, in indirect sunlight for a further seven days, agitated daily before triple straining the marc through a sieve twice then through muslin. The CO menstruum was bottled in labelled dark amber bottles and stored in a dark cupboard.

Step Two – Extraction in Oil

500 gm of dry *C.officinalis* flowers were bottled with a 1000 ml oil mix which consisted of 50% Omega-3 pure marine oil (Kentucky Equine Research (KER) EO3) and 50% Flax Oil (Stoney Creek cold pressed flaxseed oil). The bottle was kept at warm room temperature, protected from direct sunlight, for four weeks with daily gentle agitation. The menstruum was collected after straining the marc through a sieve twice then through muslin. The CO menstruum was bottled in labelled dark amber bottles and stored in a dark cupboard.

Step Three

1000 ml of CO oil was prepared using 500 ml of each menstruum from Steps one and two above. The final blend of CO oil was dispensed accordingly to the test horses and participants.

The horses in this study included a 11-year-old Warmblood (WB) mare (Horse 1, 650 kg bodyweight (bwt)), a 10-year-old WB gelding (Horse 2, 630 kg bwt), a 9-year-old WB gelding (Horse 3, 580 kg bwt) and a 8 year old WB gelding (Horse 4, 590 kg bwt) acted as a control, all horses were retired from work and paddocked 24 hours a day. For two days prior to gastroscopy, horses were fed as described in Table 1. The horses were prepared for gastroscopy by receiving their normal night feed at 6 pm after which all feed was withheld until gastroscopy the following morning, allowing a minimum 12 hour fast to ensure an empty stomach. Water was not withheld during the night.

All horses were lightly sedated with Butorphanol 10 microgram/kg IV (Ilium "Butorgesic" Butorphanol 10 mg/ml) and Detomidine 10 microgram/kg IV (Virbac" Dozadine" Detomidine 10 mg/ml).

Results

After a 12 hour fast with water access, all Warmblood horses had a small area of the squamous mucosa at the lesser curvature thinly coated with a glossy, yellow film (Table 1; Figure1). From personal communications from participant gastroscopy, ponies underwent a 12 hour fast with water withheld for 6 hours prior to the gastroscope. All ponies were reported to have a significant covering of squamous and glandular mucosa with a thick, glossy yellow film that could be easily washed away with water (Table 2; Figure 2). No CO was observed in the control horse (CO: *C.officinalis* infused Omega-3 and flax oil mix PO: Plain Omega-3 and flax oil).

Table 1. Gastroscopy Findings – horses routinely paddocked, study horses

Horse	Treatment	Result
1 650 kg	Wet beet pulp mash 30 ml CO	Squamous mucosal thinly coated at lesser curvature
2 630 kg	Dry pellet feed 30 ml CO	As above
3 580 kg	Wet lupin mash 30 ml CO	As above
4 590 kg	Wet beet pulp mash 30 ml PO	Control - nil mucosal coating

Table 2. Gastroscopy Findings - ponies routinely stabled, personal communication

Participant	Treatment	Result
(A) Pony 430 kg	Wet lupin mash 10 ml CO	Complete and thick squamous and glandular mucosal coating
(B) Pony 280 kg	Wet lupin mash 10 ml CO	As above
(C) Pony 300 kg	Wet lupin mash 10 ml CO	As above
(D) Pony 330 kg	Wet lupin mash 10 ml CO	As above

Discussion

The aim of this study was to investigate whether coating of the gastric mucosa by the CO reported via personal communications, from gastroscopy in ponies fed the CO, could be repeated in all horses in the study, fed the same CO. The results (Table 1) show that after a 12 hour fast, CO does coat the gastric mucosa but, in this study, only small areas were coated. Unexpectedly, there was a significant difference between the thickness and area of gastric mucosa coating between the reported gastroscopy findings (Table 2) in the stabled ponies (complete squamous and glandular mucosa thickly coated) compared to paddocked Warmblood horses (small area of squamous mucosa at lesser curvature thinly coated). Explanation for possible differences in these results are examined.

Passage Rate of Ingesta

Mean retention time (MRT) describes the passage rate of ingesta through the gastrointestinal tract (GIT). In the equine stomach, most of the ingesta is held for 2- 6 hours (Van Weyenberg 2006). Studies on GIT transit times and MRT in horses and ponies have shown significant differences associated with husbandry (stabling vs paddock), feed restriction, feed type, feed composition and bodyweight (Pearson 1991.) In stabled horses, when food intake stops, peristalsis slows and passage rate of feed decreases (Van Weyenberg 2006). Ponies on restricted feed were associated with the highest MRT whereas access to pasture was associated with accelerated passage rate of ingesta (Van Weyenberg 2006).

Gastrointestinal motility is more active and maintained in paddocked horses (William 2011) and the paddocked horses in this study, who also had access to water during the night, have effectively flushed almost all traces of food and oil from the stomach. The ponies, however, were kept under routine stable conditions, had water withheld and therefore the MRT in the ponies may be expected to be slower, thus potentially offering the opportunity to display adhesion of the CO to the mucosa.

Critical Period and Modifications to Methods

With numerous variations in possible MRT, focus for further study should be on the critical time when gastric mucosa protection is required. In the stabled horse, this would generally be during the night, 4-6 hours after the consumption of the nighttime feed which is generally given around 4-6 pm. It is thus proposed that this is the time to examine the stomach contents to identify whether the CO is adhering to the mucosa. Performing the gastroscopy 12 hours after the last feed will only visualise a stomach that is empty i.e. the ideal protocol for ulcer examinations. However, we are not looking for ulceration; we are interested in what is happening in the stomach by the CO during the critical period stated.

Compound Extraction and CO Analysis

Knowing the exact chemical composition of the CO oil with respect to mucilage content, would be informative however requires laboratory analysis, beyond the scope of this study. Extraction techniques can be further explored. Roja-Bedoya (2020) showed that ultrasound-assisted extraction techniques obtained the major quantities of flavonoids and carotenoids in *C. officinalis*.

Conclusion

The results of this study show that there was a significant difference in the amount of gastric coating by the CO in horses kept under different husbandry conditions. Examining stabled horses of different bodyweights, 4-6 hours after their last feed, would be a next step to investigate potential adherence of the CO to the gastric mucosa. Further study could then investigate if CO offers a protective role in the equine gastric mucosa. Although in this study only a small area of CO coating was observed in this study, the CO present was situated around the lesser curvature. This is important because of the location of ulcers; knowing the location and severity of ulcers

in EGUS can assist with treatment planning. ESGD commonly affects the non-glandular squamous mucosa of the stomach, particularly along the lesser curvature (Vokes 2023). Equine gastric ulcers are a common problem affecting health and performance, so development of an organic, easy to administer and relatively economical protective supplement would be a valuable addition to management of EGUS.

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Appendix 1.

Figure 1. Gastroscope pictures - Study Horse 1

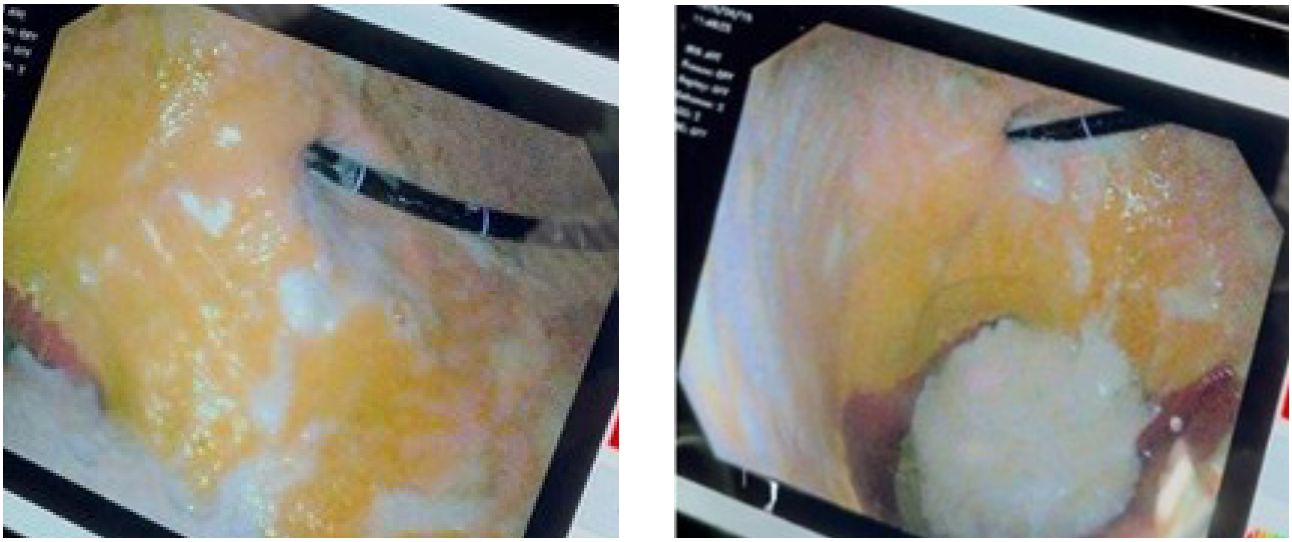
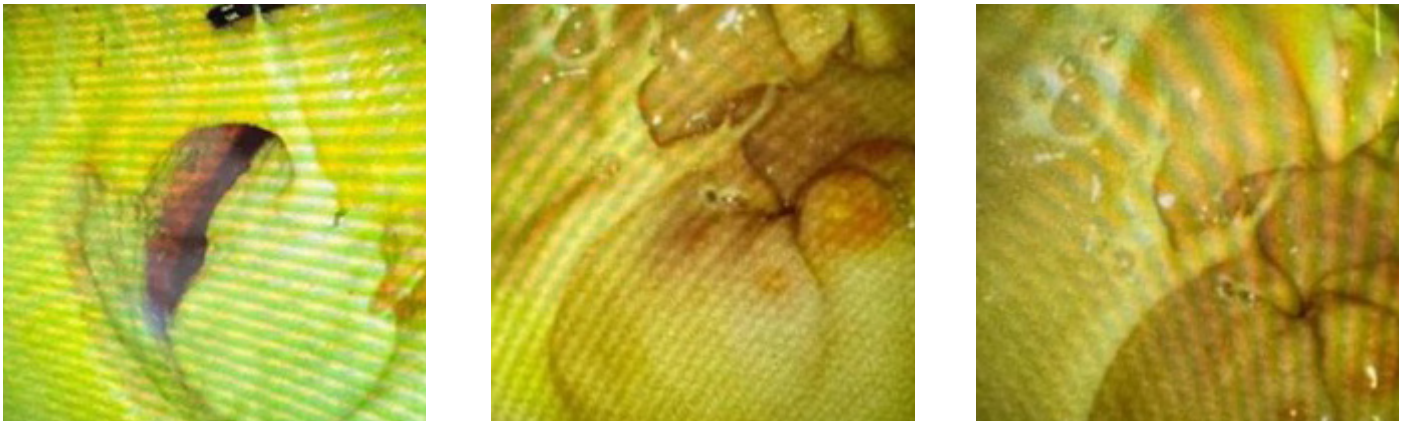


Figure 2. Gastroscope pictures - Participant Pony A



Monograph

Wholefoods as a Source of Disease-Modifying Nutrients

Dr Mio Shinohara Royce, New South Wales, Australia
BVM, PhD, GDVCHM, GDVWHM

Dr Mio Royce is an integrative veterinarian and CIVT faculty member with a research background in molecular medicine. She has completed two graduate diplomas with CIVT in veterinary Chinese and Western herbal medicine.

Essential nutrients play key roles in disease prevention and treatment. While dietary supplements are readily available, incorporating wholefoods in our patient's diet offers additional benefits. Wholefoods provide a balanced blend of vitamins, minerals and fatty acids in the most natural forms, often complexed with cofactors and activating enzymes. This food matrix helps to improve their bioavailability while buffering potential side effects. Better yet, wholefoods are more than the sum of essential nutrients. They are packed with phytonutrients, probiotics, fibers, organic acids and many more, which synergically work together in an intricate way we cannot replicate by using isolated synthetic supplements.

This nutrient checklist below was created to help practitioners to naturally elevate certain nutrient levels for the management of everyday health and various diseases. Click HERE to download the checklist.

	Animal-derived	Seafood	Plant/Fungus
Macrominerals			
Calcium	□ RMB □ Eggshell	□ Small whole fish □ Algae calcium	
Phosphorus	□ Any	□ Any	□ Rice bran □ Yeast □ Pumpkin seeds □ Wheat germ
Magnesium	□ RMB □ Eggshell □ Chicken □ Pork	□ Kelp	□ Seeds† □ Dried basil □ Rice bran □ Nuts‡
Sodium		□ Sea salt & rock salt	
Potassium		□ Seaweed	□ Leafy greens □ Banana
Chloride		□ Sea salt & rock salt	
Microminerals			
Heme iron	□ RMB □ Red meat □ Liver □ Spleen □ Lung	□ Clams □ Tuna	
Copper	□ Liver □ RMB	□ Spirulina □ Krill □ Octopus □ Oyster	□ Nuts‡ □ Seeds† □ Dried basil □ Yeast
Zinc	□ RMB □ Liver □ Beef □ Lamb	□ Oyster □ Crabmeat	□ Seeds† □ Wheatgerm □ Dried maitake
Manganese	□ RMB	□ Clams	□ Cinnamon □ Ginger □ Turmeric □ Blueberry □ Hemp seeds □ Acai
Selenium	□ Kidney	□ Bonito □ Tuna □ Flounder	□ Brazil nuts
Iodine		□ Seaweed	
Boron*	□ RMB	□ Algae calcium	□ Broccoli □ Peaches □ Peanut □ Apples
Chromium*	□ RMB □ Spleen □ Liver	□ Sea lettuce	□ Nettle □ Yeast □ Acai □ Oat/wheat/barley grass
Molybdenum*	□ RMB □ Pork liver	□ Nori seaweed	□ Soy/edamame □ Oats □ Legumes

Silicon/silica*	□ RMB with cartilage	□ Algae calcium	□ Burdock □ Oats □ Leafy greens □ Sweet potato
Vanadium*		□ Shellfish □ Algae calcium	□ Mushrooms □ Black pepper □ Dried parsley
Vitamins (Fat Soluble)			
Vitamin A	□ Liver □ Egg yolk	□ Cod liver oil	□ Carrots (dogs only)
Vitamin D	□ Egg yolk	□ Sardine □ Salmon □ Cod liver oil	
Vitamin E	□ Egg yolk	□ Salmon	□ Sunflower oil □ Almond □ Wheatgerm
Vitamin K*	□ Poultry □ Lamb	□ Seaweed	□ Parsley □ Leafy greens □ Natto
Vitamins (Water Soluble)			
Vitamin B1 (Thiamine)	□ Lean pork □ Egg yolk □ Organ meats	□ Nori seaweed	□ Yeast □ Rice bran □ Miso □ Wheatgerm
Vitamin B2 (Riboflavin)	□ Liver □ Kidney □ Heart	□ Nori seaweed □ Spirulina	□ Yeast □ Dried parsley □ Dried mushrooms
Vitamin B3 (Niacin)	□ Chicken □ Liver	□ Sockeye salmon □ Tuna □ Bonito	□ Yeast □ Rice bran □ Dried maitake & shiitake
Vitamin B5 (Pantothenate)	□ Poultry □ Liver □ Kidney □ Heart □ Egg yolk		□ Mushrooms □ Broccoli
Vitamin B6 (Pyridoxine)	□ Poultry □ Liver □ Lean pork □ Venison	□ Tuna □ Bonito □ Bream	□ Rice bran □ Yeast □ Wheatgerm □ Dried basil, parsley & sage
Vitamin B9 (Folate)	□ Liver □ Kidney □ Egg	□ Nori seaweed	□ Dried parsley □ Cruciferous vegs □ Asparagus □ Yeast
Vitamin B12 (Cobalamin)	□ Liver □ Kidney □ Yogurt	□ Salmon □ Clams □ Sardine □ Oyster	
Vitamin C*		□ Nori seaweed	□ Fruits □ Bell pepper □ Broccoli □ Kale
Other			
Choline	□ Egg yolk □ Liver □ Kidney □ Tripe	□ Salmon □ Fish roe □ Krill oil	□ Dried maitake □ Lecithin
DHA & EPA (Omega 3)		□ Oily fish □ Mussels □ Fish/krill/algae oil	
Linoleic acid (Omega 6)	□ Poultry □ Egg □ Meat fat		□ Vegetable oil
Taurine*	□ Lamb □ Turkey □ Duck □ Heart	□ Tuna □ Mackerel □ Salmon	
Biotin*	□ Egg yolk □ Liver □ Kidney	□ Flounder	□ Yeast □ Almond □ Mushrooms
Fibers*	□ Skin □ Tendon □ Tripe	□ Seaweed	
Probiotics*	□ Plain yogurt & kefir □ Natural cheese □ Green tripe		□ Root vegetables □ Mushrooms □ Seeds†
Digestive enzymes*	□ Pancreas □ Honey □ Green tripe		□ Sauerkraut □ Miso □ Coconut yogurt
Chondroitin* Glucosamine*	□ Bone broth □ Poultry feet □ Cartilage		
β-Glucans*			□ Mushrooms □ Nutritional yeast

DHA = docosahexaenoic acid; EPA = eicosapentaenoic acid; RMB = raw meaty bone and bonemeal.

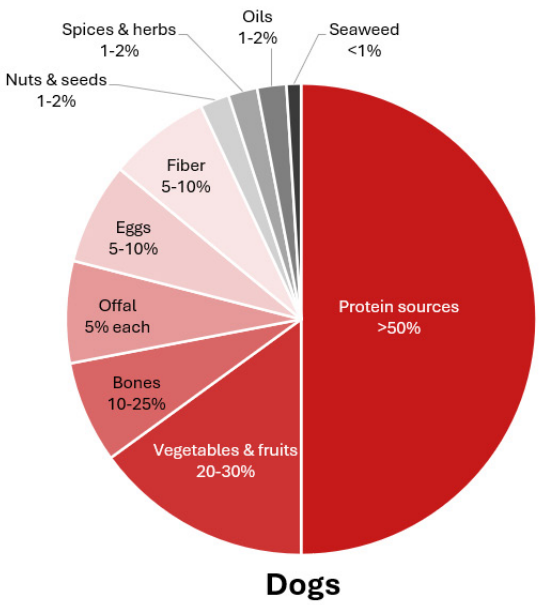
* Currently considered non-essential but have important health benefits. Taurine is essential for cats and some dog breeds predisposed to dilated cardiomyopathy.

† Examples of seeds include sesame, pumpkin, flax, hemp, sunflower and chia.

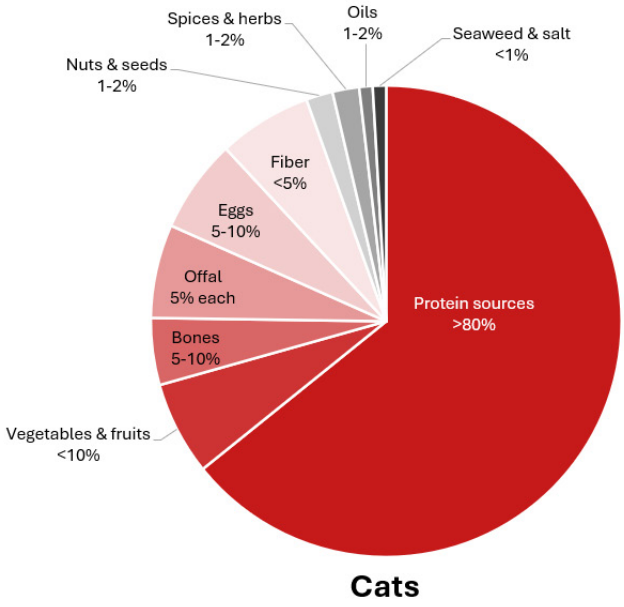
‡ Examples of nuts include almonds, pinenuts, hazelnuts and walnuts.

How Much to Give?

Even though natural foods are beneficial, we still don't want to overfeed or underfeed. The following charts provide a general guideline for balanced diet compositions. As an example, when you want to increase vitamin A intake and decide to use liver (offal), 5% of the total diet (5 g per 100 g) is a good starting point. Animal Diet Formulator and USDA FoodData Central are also useful resources to check how much nutrients each food contains.



Dogs



Cats

Monograph

Turkey Tail Mushrooms for Veterinary Applications

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Dr Robert Silver is the creator of and tutor for CIVT's Essentials of Veterinary Medicinal Mushrooms course and the Chief Veterinary Officer for Real Mushrooms. This article has been revised and published with the consent of Real Mushrooms.

Turkey Tail Mushroom Facts

Turkey tail is the common name for the *Trametes versicolor* mushroom (formerly named *Coriolus versicolor*). It derives its name from its appearance, that looks very much like the tail of a turkey. This mushroom is very common and can be found worldwide, growing on dead and dying logs.

It is a member of the basidiomycete phylum in the fungal kingdom. It is called a "polypore" mushroom due to the pores that open on its underside, that are the growth chambers for the haploid spores it produces. The main function of the mushroom part of the life cycle of this fungus is to grow the spores, protect them while they mature, and then release them to propagate the species. These mushrooms are commonly found on trees, a distance above ground, which allows the wind to disperse these spores far and wide to ensure continuation of this mushroom species.

Traditionally, the turkey tail mushroom has been used extensively for at least 2000 years in Traditional Chinese Medicine (known as *yun zhi*), and as a part of indigenous medical practices worldwide. The mushroom has been dried and powdered and then administered as an infusion or decoction for general health and longevity, for physical endurance and strengthening, lung diseases, to improve energy, and support health during chronic illness (Hobbs 2020).

Turkey tail contains unique polysaccharides such as the peptidopolysaccharides which have a peptide side branch to the beta-glucan main chain and are found in both the fruiting body (mushroom itself) and its mycelium. Turkey tail mushroom has the highest beta glucan content of any mushroom, one good reason for its extensive use as a health supplement.

The turkey tail mushroom also contains other secondary metabolites that have strong influences on health. It contains, second to reishi mushroom, the largest number of terpenes of all the mushrooms. Terpenes have strong health influences on inflammation, immune modulation and neoplastic activity.

Sterols, such as ergosterol and ergosterol peroxide are also present in the turkey tail mushroom. Phenolic antioxidant and anti-inflammatory compounds such as quercetin, catechin, baicalein and baicalin are also found in this mushroom.

The synergistic effect of the many active ingredients found in the turkey tail mushroom are what give it a very potent influence on many health conditions. This mushroom has undergone extensive scientific examination to document its many potential actions.

Nearly all of these studies have been performed in humans or laboratory animals. Conditions that turkey tail can benefit based on these studies include (Carroll 2023):

- Chronic bronchitis
- Cancer
  - Breast cancer
  - Colorectal cancer
  - Gastric cancer
  - Liver cancer
  - Lung cancer
- Dysbiosis
- Hepatitis
- Human papillomavirus
- Hyperlipidemia

- Immunological function
- Meniere's disease and neuroinflammation

Turkey Tail Mushroom Benefits

The turkey tail mushroom contains a number of different molecular variations of beta glucans. Each beta glucan is slightly different than the other. It is this multitude of similar but different beta glucan molecules that gives turkey tail its quality of robust immune enhancement. This enhancement manifests as increased host defenses against viral, fungal and bacterial infections. It also strengthens the host immune system to be able to detect and remove the mutated cells that can become cancer cells, thus helping to keep the host healthy, regardless of the immune challenges.

Triterpenes in the turkey tail mushroom are, like the beta glucans, found in a variety of molecular variations, all of which have potent bioactivity against infectious agents and neoplastic cells. These hydrocarbon polymers work together synergistically with each other and with the many beta glucan molecules provided by the mushroom to create the therapeutic profile of immune effectiveness for which turkey tail is so well known.

Cancer

Historically, the turkey tail mushroom has been considered to be supportive in treating cancer in human beings. The mycelial fractions, the Chinese derived polysaccharopeptide, PSP, and polysaccharide-Krestin, the Japanese derived PSK or Krestin, have been in use in Asia concurrently with chemotherapy for many decades with presumed benefits and safety for human patients presenting with a variety of cancer diagnoses.

The Chinese company that owns the patent on PSP, funded two studies at the University of Pennsylvania. The first one was a pilot study to determine the most effective dosage to use. It was published in 2012 (Brown & Reetz 2012). A small number of dogs (five dogs in each cohort) were administered a pharmaceutical extract of the turkey tail mycelium grown in liquid culture, known as the PSP fraction. The study found improved survival times in dogs with naturally occurring splenic cancer, hemangiosarcoma, in the group given the highest dosage of the PSP, 100 mg/kg/day. The survival times were greater than historical controls for survival time, even with chemotherapy.

This first study was heralded as proof that mushrooms can effectively treat cancer. The oncologists, though, said not to jump to conclusions as this was only a Phase I study and involved only five dogs in three groups, or 15 dogs total.

A larger, prospective, randomized clinical trial was finally published (Gedney et al. 2021) ten years after the initial pilot work. It was a randomized placebo control clinical trial that evaluated the benefit of the PSP fraction in a larger number of dogs with hemangiosarcoma using that highest dosage found to be successful in the pilot study.

This second study had three cohorts. The largest cohort (50 dogs) received the turkey tail extract alone. The second cohort of 25 dogs received chemotherapy and the turkey tail extract. The third cohort of 25 dogs received chemotherapy and a turkey tail extract placebo. This study followed these 100 dogs until they died from the cancer. It found no statistical benefit to the use of PSP in these dogs, either with chemotherapy or without, however the numerical trend was supportive that the turkey tail did provide some measure of benefit to mean survival times.

There were several observations of the data derived from this study that bear looking at and can be useful to veterinarians who are faced with helping their clients decide to treat or not to treat, and what treatments to use with their hemangiosarcoma patients. The most common statistic for mean survival time for hemangiosarcoma patients who are splenectomized but do not receive chemotherapy is just a few months (one to three months). Patients who are splenectomized and receive the standard chemotherapy of doxorubicin have a mean survival time of eight months, or 240 days (Wendelburg et al. 2015). This study's hypothesis was that the mushroom extract was superior to the standard therapy of splenectomy and doxorubicin chemotherapy. When statistics were applied to the data, this hypothesis could not be proven.

However, there were other findings of note that veterinarians can use when recommending splenectomy and treatment for hemangiosarcoma. For instance, it was found that out of the 100 dogs,

male dogs did substantially better than female dogs. Second, if the hematocrit of the patient on diagnosis was greater than 30% the prognosis was also much better. Finally, and this is common sense, the stage of the cancer at the time of diagnosis also dictated mean survival time. The greater the stage the lower the mean survival time.

The cohort of dogs receiving just the turkey tail extract, that were male, and presented with hematocrits greater than 30%, had a mean survival time of 240 days, which is a little less than dogs who received chemotherapy alone. In this study that was around three months longer than the non-chemotherapy group, dogs who received both the chemotherapy and the turkey tail extract had the longest mean survival time of the three groups, nearly 450 days!

Once scientists had a single molecule (the turkey tail extract – PSP) to test against cancer models or clinical cancer cases, they stopped using the turkey tail mushroom (fruiting body). Not because turkey tail doesn't benefit cancer patients, but in scientific research it's desired to use a single molecule test material versus the very complex and variable number of active ingredients in the mushroom itself. This control of the variables with a single test molecule creates data that is more precise than if there were multiple actives in the test material. However, in the "real world", the more actives you have in a mushroom the more potent it is as a therapeutic.

It is probable that the turkey tail mushroom extract, versus the pharmaceutical mycelial extracts of PSP and PSK, may have had better effectiveness against cancer simply due to the many bioactive molecules found in the mushroom as compared to the single extracts. When treating a cancer patient these multiple components work together synergistically to improve immune function and have cytotoxicity to neoplastic cells.

Both the PSP and PSK extracts have had good objective measured benefits in a number of human cancer diagnoses from many published studies performed since the 1980's when these extracts were developed and patented. It is likely that either the hemangiosarcoma cancer in dogs is not as responsive as some of the other cancers for which the PSP and PSK fractions were successful, or that the dosage used for this study, in spite of the successful pilot study, was too low.

In fact, one of the conclusions of the first hemangiosarcoma study was that there is a direct dose response curve when it comes to treating hemangiosarcoma. We saw the 25 mg PSP group not do as well as the 50 mg PSP group, and both didn't do as well as the 100 mg PSP group. The question is, if a dose of 200 mg/kg were used, would we have had better statistical significance?

Immune System Support

Turkey tail mushroom contains a number of compounds, all of which have beneficial effects on immune system health and functioning. The numerous variations of the beta glucan molecules are one strong immune-supportive category of molecules commonly found in the turkey tail mushroom. Terpenes, both triterpenes and sesquiterpenes, are a second source of the strong immune-enhancing compounds found in the extracts of the turkey tail mushroom. These hydrocarbon polymers are not water soluble, but they are large molecules and thus do not evaporate when the dried mushroom powder is decocted at 90° C for two hours in the hot water extraction process. Mushroom terpenes have many beneficial effects, including antioxidant and anti-inflammatory activity. The hot water extracts also contain the potent antioxidant and anti-inflammatory flavonoids, quercetin, baicalein, baicalin and catechin (Habtemariam 2020).

These many different "immune system-positive" compounds found in the turkey tail mushroom are one good reason why this mushroom in particular is so good in its support of a robust immune system response to challenges such as infections, immune deficiencies and cancer in our pets.

The antioxidant and anti-inflammatory effects of

these many bioactive molecules in this species have led to several studies in humans and laboratory animals exploring the value of turkey tail mushroom with respect to obesity, diabetes, osteoarthritis (Wank et al. 2019) and inflammatory bowel disease (IBD) (Lim 2011). One study found that the turkey tail mushroom could also induce analgesia, or mild pain relief, due to the effect of its polysaccharides increasing the cytokine, IL-2, which can reduce inflammation, and subsequently, mild pain and discomfort (Gong et al. 1998).

Published studies in experimental animals also found a protective effect of turkey tail mushroom on alcoholic liver damage. Not a problem in our pets, but we expose them to other liver-toxic drugs, like steroids and chemotherapy agents, as well as environmental sources of liver toxicity. This mushroom was also able to protect the heart from damage secondary to diabetes in experimental models.

One application for the turkey tail mushroom in the human two-legged animal is for Chronic Fatigue Syndrome, which has been linked to an infection with the Epstein-Barr virus. The mushroom has been found, as mentioned above, to have liver protective properties, and to help, as most mushrooms do, with cholesterol and triglyceride levels in humans. Studies have found antimicrobial activity of the turkey tail mushroom extracts for fungal pathogens such as candida, which is not a very common problem in dogs. Activity was also found for some pathogenic bacterial species. As with cancer, the turkey tail mushroom extract has a dual effect of mobilizing the immune system to defeat the microbial pathogens and a direct cytotoxic effect on the pathogens.

Potential Canine Applications

What are possible uses for this versatile mushroom species? Some areas where turkey tail could help our canine friends are suggested by its well-studied properties of:

1. Immune enhancement
2. Cytotoxicity to both cancer and infectious agents
3. Antioxidant
4. Anti-inflammatory.

Vaccine titer protective immunity

A 2011 study looked at the ability of shelter puppies who were stressed, and thereby immunosuppressed, to achieve protective antibody levels from rabies vaccinations. Most of the puppies in this study were unable to be protected from their rabies vaccination. After a month's immune system conditioning with a beta glucan extract of the oyster mushroom, these puppies were able to achieve protection from being revaccinated for rabies due to the immune restorative benefits of the beta glucans in the oyster mushroom extract (Haladova 2011). The beta glucans found in turkey tail have been found to be some of the strongest for improving immune system function. I have no doubt that turkey tail mushroom could also help improve vaccine competence, just as the oyster mushroom extract did in this cited study.

Another study explored the benefits to rabies vaccination using extracts of the reishi mushroom and confirmed that mushroom beta glucans can improve rabies vaccine competence (Paris et al. 2020).

Concurrent Use of Turkey Tail with Conventional Therapies for Better Outcomes

There are many situations where your patient could benefit from adding turkey tail mushroom extracts to their daily supplement program to improve immune function to help resolve problems, such as chronic infections, especially involving respiratory, skin or urinary issues. Used concurrently with antibiotics, by mobilizing immune system activity, these conditions may respond better, than without their use.

The fiber in the turkey tail mushroom is microbiome supportive, so when the antibiotics are used to treat chronic infections, the mushroom fiber and beta glucans will help to restore a healthy microbiome balance that becomes destroyed with the use of antibiotics.

Cancerous conditions are a complex problem, needing complex solutions that:

- Support your patient's immune system
- Help them better withstand the rigors of conventional cancer therapies
- Help to reduce the toxic effects of cancer growth.

Turkey tail has been used over the centuries in humans for this purpose. The use of this mushroom would be likely to improve your patient's response to whatever its diagnosis.

Administration Guide for Mushrooms

The amount of mushroom you give your patient is dependent upon several factors:

1. The weight of the patient
2. The severity of the patient's condition
3. The potency of the mushroom – is it dried powder, or has it been hot water extracted and concentrated into an extract ratio
    a. What is the extract ratio?
        i. 1:1
        ii. 8:1-10:1

In traditional Chinese medicine, dosages for humans are expressed as a range of grams per day of the dried and powdered, but not extracted, mushroom.

- Maintenance or Wellness: 1-3 g/day
- Therapeutic (general): 3-6 g/day
- Therapeutic (extreme/acute):6-9 and as much as 30 g/day in selected cases

If we apply Clark's Law to prorate these doses based on the lower weight of our animal patients than the average human weight, we do that by making a ratio of Patient Weight/Average Human weight of 150 pounds (70 kg). By prorating the human dose to the weight of your animal patient, we can use these guidelines chart to figure out an appropriate starting point for our dosing.

Furthermore, if you are using concentrated extracts, you would not need as many grams of dried unextracted powder.

For instance, if your patient weighs 50 pounds, and you wanted to give the middle range of 6 grams of powdered mushroom daily, you would be giving to this dog 30% of that or 2 grams of dried powder. If you had a 1:1 extract, that is how much 1:1 extract you would give, because this extract is the same concentration as the dried powder, but is more bioavailable. If you were using an 8:1 extract ratio powder, you would use 1/8 of that 2 grams, or 250 mg of the 8:1 extract.

These are considered starting doses.

You can adjust up or adjust down as your patient responds to the dosage. I always recommend starting lower than the computed dosage to allow your patient to accommodate to a new supplement without developing some of the adverse reactions we do see on occasion with the administration of mushrooms. We can see some soft stools or frank diarrhea, usually due to the extra high fiber content, and in some especially sensitive individuals we can see some vomiting or appetite loss. The rare dog will develop a hypersensitivity reaction to a specific mushroom or to fungi in general, so be aware of that possibility.

Turkey Tail Mushroom Safety

Turkey tail (*Trametes versicolor*) mushrooms have been in use by humans for thousands of years without evidence of any toxicity to the people who have used them. Due to this observed safety over those many years turkey tail has been in use, it has established for itself anecdotally, to be presumed safe, and never with any measured toxicity. It is for this reason that objective safety and toxicity studies are rare to find in the world scientific literature for turkey tail and most other medicinal mushrooms.

One study, published in 2011, administered a variety of different doses and forms of the turkey tail mushroom hot water extract to laboratory rats. Doses of the extract were administered at 1250, 2500 and 5000 mg/kg as a single dose, and as a daily dose given for 28 days. Observations of rat mortality, impact on their behavior, adverse events and relative organ weights were measured and histological, hematological and biochemical measurements were taken. There was no observed evidence of toxicity at any of these escalated dosages.

These findings confirm what has been observed for

thousands of years, that turkey tail mushroom is safe to use for long periods of time at significantly higher doses than commonly are used for health and wellness.

A safety study for turkey tail that specifically tests high dosages of the mushroom in dogs as the target species, has yet to be conducted, and is needed to ensure that the high dosage use of turkey tail in dogs for serious problems such as neoplasia and viral infections has objectively been proven safe in the canine (Hor et al. 2011).

Summary

Turkey tail mushroom and its extracts have proven themselves to be effective clinical tools for veterinarians to choose when their patients are faced with a variety of conditions, both serious and life threatening, or important for the maintenance of quality of life.

Choose a product that gives you full transparency on its product label and question the company as pertains to its cultivation practices, its quality control and its extraction process. Certificates of Analysis provided by the company, conducted by independent certified analytical laboratories, will give objective evidence of product quality, potency and freedom from contamination.

Some companies sell mycelium that is grown on grain, which highly dilutes the potency of the mycelium, which is the source of the commercial PSP and PSK extracts when cultivated in a liquid culture. But in solid-state fermentation of grain you can't separate the mycelium from the cereal, and the remainder of the mycelial biomass is mostly carbohydrates in a tempeh-like material.

Read the product label carefully to avoid selecting a less-than-potent product that is not a mushroom and is not a potent form of mycelium. Give-away clues on the label to look for are the words "mycelial biomass", and a statement of an organic grain, such as rice or oats.

The product you select may have a bearing on the success of your therapy, so choose wisely! Most veterinarians once they have experienced the successful outcomes that are so common when mushrooms are included in a treatment protocol become true believers in this emerging but rapidly growing treatment modality.

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Research Updates

Serum Metabolomics of Senior Dogs Fed a Fresh, Human-Grade Food or an Extruded Kibble Diet

Yamka R, Sires R, Wakshlag J and Huson HJ, 2025, 'Serum Metabolomics of Senior Dogs Fed a Fresh, Human-Grade Food or an Extruded Kibble Diet', *Metabolites*, 15(10):676.

Abstract

Background/Objectives: Despite the growing popularity of fresh food for dogs, there is an extremely small amount of literature evaluating the potential health benefits of fresh food and reduced processing compared to traditionally processed shelf stable cans, extruded kibble or other food formats. Additionally, aging dogs have been previously documented to have altered metabolism and nutritional needs compared to a healthy adult dog population, but these differences are not well defined. The objective of the study was to compare the effects of feeding a fresh, human-grade food versus a standard extruded kibble diet in a year-long longitudinal study on serum metabolomic profiles in senior dogs.

Methods: Twenty-two healthy mixed-breed geriatric Alaskan sled dogs were age- and sex-matched into two feeding groups. All dogs were fed the extruded diet (control) for a four month washout period prior to being transitioned into their respective treatment group. Group One continued to be fed the control diet, while Group Two was transitioned to a fresh, human-grade food (treatment). Body weight and body condition were assessed monthly, and calorie intake was adjusted to maintain body weight. Individual serum samples were collected at day 0 and months 1, 3, 6 and 12. Metabolomic profiling of serum samples was performed by Metabolon, Inc. (Durham, NC, USA). Data was analyzed using two-way analysis of variance with repeated measures to determine treatment differences.

Results: Dogs fed the treatment food had an increase in branched-chain amino acid metabolism, creatine, carnosine, anserine, fatty acid metabolism, long-chain n-3 fatty acids, lipolysis and ketogenesis. The treatment group had decreased advanced glycation end products, fatty acid synthesis and creatinine.

Conclusions: This study is the first long-term feeding study evaluating serum metabolomics in dogs that demonstrates the dramatic and sustained impact that diet can have on canine metabolism.

Please click **HERE** to read the full research paper.

Ex Vivo Energy Restriction in Obese Cats Reveals More Amino Acid and Vitamin Intakes Below Recommendations with Over-The-Counter Compared to Veterinary Weight-Loss Diets

Grant CE, Shoveller AK, Blois S, Bakovic M, Monteith G and Verbrugghe A, 2020, 'Dietary intake of amino acids and vitamins compared to NRC requirements in obese cats undergoing energy restriction for weight loss', *BMC Vet Res* ,16, 426.

Abstract

Objective: To determine whether cats meet National Research Council (NRC) recommendations for essential nutrient intake when energy restricted on various diets.

Methods: Three diets for each diet group - veterinary weight loss, over-the-counter low calorie (LOWCAL) and OTC adult maintenance (ADULT) - were analyzed for amino acids and vitamins. Theoretical nutrient intakes with each diet under energy restriction were calculated using body weight (BW) and body condition score data of 16 adult obese cats from a previous in vivo weight-loss study. Six energy calculations (R1–6) were used: R1, 70 kcal/current $BW^{0.75}$; R2, 0.8 X 70 kcal/$cBW^{0.75}$; R3, 70 kcal/ideal BW $(iBW)^{0.75}$; R4, 0.6 X 130 kcal/$cBW^{0.4}$; R5, 0.8 X 70 kcal/$iBW^{0.75}$; and R6, 0.6 X 130 kcal/$iBW^{0.4}$. Calculated intakes were compared to NRC recommended allowance (RA) and minimum requirements for adult cats.

Results: Crude protein intake was below RA for LOWCAL at R4 and ADULT at R6 and below minimum requirements for ADULT at R6. Tryptophan and phenylalanine plus tyrosine intakes were below RA for ADULT at R4. Choline intake was below RA for veterinary weight loss at R2 and R4 through R6, for LOWCAL at R4 and R6, and for ADULT at R1 through R6.

Conclusions: Theoretical energy restriction using purpose-formulated weight-loss food resulted in

only choline being below NRC recommendations. Most nutrient intakes met NRC recommendations for LOWCAL and ADULT, except for crude protein, tryptophan, phenylalanine plus tyrosine and choline intakes.

Clinical Relevance: Veterinary professionals should exercise caution when restricting energy for weight loss, particularly with over-the-counter diets, as they may not meet essential nutrient requirements at lower caloric intakes. Veterinary weight-loss foods are recommended to reduce the risk of nutrient deficiencies.

Please click **HERE** to read the full research paper.

Effect of a Homemade Diet Compared to a Commercial Diet on Glycaemic Variability and Glycaemic Control Assessed by Continuous Glucose Monitoring System in Diabetic Dogs: A Randomised Crossover Study

Tardo AM, Vecchiato CG, Gherlinzoni E, Corsini A, Corradini S, Del Baldo F, Biagi G and Fracassi F, 2025, 'Effect of a homemade diet compared to a commercial diet on glycaemic variability and glycaemic control assessed by continuous glucose monitoring system in diabetic dogs: a randomised crossover study', J *Small Anim Pract*, Aug 22.

Abstract

Objectives: To evaluate the effects of a homemade diet and a commercial diet on glycaemic control and glycaemic variability of diabetic dogs monitored with the FreeStyle Libre continuous glucose monitoring system.

Materials and methods: Prospective randomised crossover study including ten client-owned diabetic dogs on insulin treatment with good glycaemic control. Dogs were randomly assigned to receive either a moderate-fibre (total dietary fibre: 2.2 g/100 kcal ME) homemade diet or a high-fibre (total dietary fibre: 4.8 g/100 kcal ME) dry commercial diet in a 2 × 6-week period. Dogs were re-evaluated every two weeks. Clinical and clinicopathological variables, selected continuous glucose monitoring system-derived and glycaemic variability metrics, glucose nadir and postprandial hyperglycaemia were recorded. Differences between diets were analysed by a repeated measure ANOVA fitting a crossover design with pairwise comparisons.

Results: There were no differences in insulin dose and glycaemic control levels between the two dietary periods. The homemade diet significantly reduced serum cholesterol concentration (mean difference: 76 mg/dL; 95% CI: -51.97 to 204 mg/dL). The percentage of time above glucose range was significantly lower (mean difference: -22.5%; 95% CI: -43.9% to -1.08%) and the percentage of time below range higher (mean difference: 6.9%; 95% CI: 1.38% to 12.4%) during the homemade diet period. The percentage of time in range and glycaemic variability metrics were not different between the two diets.

Clinical significance: The homemade diet and commercial diet can be considered valid dietary options in diabetic dogs. The results suggest that, with regard to the diets examined, the homemade diet might have a more effective glucose-lowering effect compared to the commercial diet.

Please click **HERE** to read the full research paper.

Insect-Based Diets: Novel, Sustainable, and Nutritious Options for Dogs

Carlson A, Adolphe JL and Decatur IL, 2024, 'Insect-Based Diets: Novel, Sustainable, and Nutritious Options for Dogs', *J Am Holist Vet Med Assoc*, 77:12–20.

Abstract

Insects are an exciting novel protein source for humans, pets and feed animals. The United Nations (UN) has identified insects as a promising solution to address global food insecurity and promote sustainable, nutritious food systems. Insects are an alternative to traditional protein sources for dogs as well as a complete and highly digestible protein. As a food source, insects may provide additional health benefits, including support for digestive health, immune function, mental acuity, joint health and arthritis. In addition, insects may serve as a novel protein source for dogs with adverse food reactions. This review summarizes the environmental impact of utilizing insect protein, discusses the use of insect protein as an alternative protein source for dogs, and provides an overview of the additional benefits of insects as an ingredient for dog food.

Please click **HERE** to read the full research paper.

Effects of Diet Type on the Core Fecal Bacterial Taxa and the Dysbiosis Index of Healthy Adult Dogs

Oba PM, Roberts LJ, Geary EL, Suchodolski JS and Swanson KS, 2025, 'Effects of diet type on the core fecal bacterial taxa and the dysbiosis index of healthy adult dogs', *Front Vet Sci*, Jun 30;12:1572875.

Abstract

There is great interest in studying the canine gastrointestinal microbiome. In healthy dogs versus those with acute and chronic enteropathies, specific bacterial taxa have been identified that are consistently associated with shifts in the microbiome. A qPCR-based dysbiosis index (DI) that assesses microbiome shifts was developed based on a subset of these taxa. Because most dogs consume kibble diets, published data on core bacteria and the DI were largely derived from dogs consuming that diet form. Because dietary composition impacts the microbiome, it was unknown whether data from dogs consuming other diet types would adhere to reported core taxa abundance and DI guidelines. The study's aim was to determine the fecal abundance of core bacteria and DI of dogs fed commercially available kibble vs. mildly cooked human-grade (fresh) diets. Fecal samples collected from adult dogs across four experiments were used (four kibble diets, n = 10-12/treatment; four fresh diets, n = 10-24/treatment). Moderate correlations were observed between total dietary fiber (TDF) and *Fusobacterium* (positive correlation), *Lactobacillus* (negative), and DI (negative). Dietary protein was correlated with fecal *Ruminococcus gnavus* (negative), while dietary fat was correlated with fecal *Bacteroides* and *C. perfringens* abundance (both positive). Dogs fed fresh diets exhibited higher ($p < 0.01$) abundances of *Streptococcus*, *Escherichia coli*, and *Clostridium perfringens*, while those fed kibble diets had higher ($p < 0.05$) abundances of *Fusobacterium*, *Clostridium hiranonis* and *Bacteroides*. Dogs fed fresh diets had a greater ($p < 0.0001$) DI, but the majority of scores remained within the normal range. Dogs fed animal protein-based kibble diets had higher ($p < 0.05$) fecal *Faecalibacterium* and *Fusobacterium,* while dogs fed animal protein-based fresh diets had higher ($p < 0.05$) *Streptococcus*, *E. coli*, and *C perfringens*. *Bifidobacterium* and *Bacteroides* were more abundant ($p < 0.01$) in dogs fed animal protein-based kibble and plant protein-based fresh diets. Dogs fed animal protein-based fresh diets had a greater ($p < 0.0001$) DI. Even though microbiota populations were statistically different among diets, all mean DI were <0, with only a few individual dogs consuming fresh diets having DI >0 (5 dogs >0; 1 dog >2). Overall, these data demonstrate the utility of the DI across different diet types in healthy dogs.

Please click **HERE** to read the full research paper.

Early Life Programming by Diet Can Play a Role in Risk Reduction of Otitis in Dogs

Hemida MBM, Vuori KA, Borgström NC, Moore R, Rosendahl S, Anturaniemi J, Estrela-Lima A and Hielm-Björkman A, 2023, 'Early life programming by diet can play a role in risk reduction of otitis in dogs', *Front Vet Sci*, Nov 6;10:1186131.

Introduction: Otitis in dogs is often chronic while local treatment primarily consists of flushing, antibiotics and/or antifungals. We were interested in finding early life variables that associate with otitis later in life, preferably some that could be modified.

Methods: A cross-sectional hypothesis-driven study with longitudinal data was performed to search for associations between pre- and postnatal exposures, and the incidence of owner-reported otitis in dogs at over one year of age. The multivariate logistic regression analysis study included data from 3,064 dogs and explored 26 different early life variables at four early life stages: prenatal, neonatal, postnatal and puppyhood. We compared two feeding patterns, a non-processed meat-based diet (NPMD, raw) and an ultra-processed carbohydrate-based diet (UPCD, dry).

Results: We report that eating a NPMD diet significantly decreased the risk of otitis later in life, while eating a UPCD diet significantly increased the risk. This was seen in different life stages of mother or puppy: The maternal diet during pregnancy ($p=0.011$) and the puppies' diet from two to six months of age ($p=0.019$) were both significantly associated with otitis incidence later in life, whereas the puppies' first solid diet, was associated in the same way, but did not reach significance ($p=0.072$). Also, analyzing food ratios showed that when puppies were consuming >25% of their food as NPMD it significantly decreased their incidence of otitis later in life, while a ratio of >75% UPCD in their

diet significantly increased their risk of otitis. Also, if the dog was born in the current family, was exposed to sunlight for more than one hour daily, and was raised on a dirt floor during puppyhood, there was a lower risk of otitis development later in life.

Discussion: The findings only suggest causality, and further studies are required. However, we propose that veterinarians, breeders and owners can impact otitis risk by modifying factors such as diet and environment.

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