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# Dietary Risk Factors and Management Strategies for Equine Colic: A Comprehensive Review

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**Abstract:** Equine colic remains one of the most common and potentially life-threatening conditions in horses, with dietary factors playing a significant role in its onset and prevention. This comprehensive review examines the dietary risk factors associated with colic, including abrupt feed changes, low forage intake, high concentrate diets, and inadequate water consumption. It also explores the pathophysiological mechanisms linking diet to various forms of colic, such as impaction, gas accumulation, and intestinal displacement. Management strategies—ranging from feeding practices and nutritional planning to the use of supplements and probiotics—are critically evaluated for their effectiveness in reducing colic incidence. By integrating current research and practical recommendations, this review aims to guide veterinarians, equine nutritionists, and horse owners in implementing dietary protocols that support gastrointestinal health and reduce the risk of colic in equine populations.

**Keywords:** equine colic, dietary risk factors, horse nutrition, gastrointestinal health, feeding management, forage intake, concentrate feed, colic prevention, equine care, nutritional strategies.

## Introduction

Colic, derived from the Greek word "kolikos" meaning "of the colon," is a ubiquitous and often perplexing term in equine veterinary medicine, representing any manifestation of abdominal pain in horses [2, 3]. Far from being a singular disease, colic is a complex syndrome encompassing a diverse array of underlying gastrointestinal disturbances, ranging in severity from mild, transient discomfort that resolves spontaneously to acute, life-threatening conditions demanding immediate and often intensive medical or surgical intervention [2, 3]. The unpredictability of its onset, coupled with the rapid progression of severe forms, makes colic a leading cause of emergency veterinary calls, significant economic burden, and, tragically, mortality in the equine industry [1].

The economic impact of colic is multifaceted and substantial. Direct costs include emergency veterinary fees, diagnostic procedures (e.g., rectal palpation, nasogastric intubation, ultrasonography, abdominocentesis), medical treatments, and potentially expensive surgical procedures and post-operative care [1]. Indirect costs, often overlooked, encompass lost training time, reduced performance in athletic horses, diminished breeding potential, and the emotional distress experienced by owners [1]. For these reasons, the prevention and effective management of colic remain paramount objectives for horse owners, trainers, and veterinarians alike, driving continuous research and the refinement of husbandry practices.

The equine gastrointestinal (GI) tract is a remarkable and highly specialized anatomical and physiological system, exquisitely adapted over millions of years for the continuous digestion of high-fiber forage [4]. This adaptation to a grazing lifestyle dictates a digestive system designed for small, frequent intakes of fibrous plant material. Key anatomical features that predispose horses to colic include:

- **Relatively Small Stomach:** The horse's stomach is comparatively small for its body size, designed for continuous, rather than large, intermittent feeding. Overfilling can lead to gastric distension and rupture, a catastrophic event.
- **Long and Convoluted Small Intestine:** The small intestine, approximately 70 feet long, is a site for enzymatic digestion and nutrient absorption. Its

length and numerous loops make it susceptible to twists, entrapments, and impactions.

- **Voluminous Hindgut:** Comprising the cecum and large colon, the hindgut is a massive fermentation vat, housing billions of microbes (bacteria, protozoa, fungi) that break down fibrous plant material indigestible by mammalian enzymes [4]. This microbial fermentation is crucial for energy extraction from forage but also produces significant amounts of gas and is highly sensitive to abrupt changes in diet. The large colon, in particular, has several sharp turns and changes in diameter (e.g., pelvic flexure, diaphragmatic flexure, sternal flexure), creating anatomical bottlenecks where impactions and displacements are common [1].
- **Fixed and Mobile Sections:** The equine GI tract has both fixed and mobile segments. The mobile sections, particularly parts of the large colon, can easily become displaced or twisted around fixed points, leading to various forms of displacement and volvulus.

These unique anatomical and physiological characteristics, while optimized for a natural grazing existence, render the modern domestic horse particularly vulnerable to gastrointestinal disruptions when subjected to management practices that deviate significantly from their evolutionary design. Modern equine husbandry often involves stall confinement, scheduled meal feeding, high-concentrate diets for performance, and intermittent access to forage, all of which can challenge the delicate balance of the digestive system.

While numerous intrinsic and extrinsic factors contribute to the multifactorial etiology of colic, including genetic predispositions, breed susceptibilities, age, sex, exercise intensity, environmental stressors, and parasitic burdens [6], dietary management consistently emerges as one of the most significant and, crucially, modifiable risk factors [1, 4, 5]. The type, quality, quantity, and method of feed delivery can profoundly influence gut motility, the intricate balance of the hindgut microbiome, and the physical characteristics of digesta as it traverses the digestive tract. For instance, abrupt changes in feed, excessive

consumption of easily fermentable concentrate feeds, insufficient intake of long-stemmed forage, and inadequate water consumption have all been strongly implicated in increasing colic risk [1, 4, 5].

Despite the widespread recognition of diet's pivotal role, the intricate mechanisms by which specific dietary components and feeding practices contribute to the diverse array of colic types (e.g., impaction, gas, spasmodic, displacement, and even some forms of strangulating lesions) are still areas of active and ongoing research. A deeper, more nuanced understanding of these complex relationships is indispensable for developing comprehensive, evidence-based feeding recommendations that can significantly reduce the incidence and severity of this debilitating condition. This comprehensive review aims to synthesize the current scientific knowledge regarding dietary risk factors for equine colic, meticulously explore the underlying physiological and pathological mechanisms involved, and delineate practical, actionable dietary management strategies for effective prevention. By critically evaluating the available literature, this review seeks to provide a valuable and accessible resource for equine veterinarians, nutritionists, and horse owners, empowering them in their collective efforts to mitigate the substantial burden of colic and enhance the overall health and well-being of domestic horses.

### Methods

This comprehensive review was conducted through a systematic and rigorous search, evaluation, and synthesis of scientific literature focusing specifically on the intricate relationship between dietary factors and the incidence of colic in domestic horses (*Equus caballus*). The methodology employed aimed to identify, critically appraise, and integrate relevant research findings from a broad spectrum of sources to provide a robust, evidence-based, and current overview of the understanding of this critical equine health issue.

### Search Strategy

A multi-database search strategy was implemented to ensure comprehensive coverage of the available literature. Electronic databases systematically searched included:

- PubMed: A primary resource for biomedical literature.

- Google Scholar: Utilized for its broad coverage, including scholarly articles, theses, books, and abstracts across various disciplines.
- Scopus: A large abstract and citation database of peer-reviewed literature.
- Web of Science: A multidisciplinary research platform providing access to high-quality, peer-reviewed research.
- CAB Abstracts: A specialized database focusing on applied life sciences, including veterinary medicine and animal science.
- VetMed Resource: Another specialized veterinary database.

The search terms were carefully selected to be broad yet specific enough to capture relevant studies without generating an overwhelming number of irrelevant results. Boolean operators (AND, OR) were extensively used to combine these terms effectively and refine the search queries. Examples of keyword combinations included:

- ("equine colic" OR "horse colic" OR "abdominal pain horse") AND ("diet" OR "feeding" OR "nutrition" OR "feed management")
- ("colic prevention" OR "colic risk factors") AND ("forage" OR "hay" OR "pasture" OR "grain" OR "concentrate feed")
- ("gastrointestinal disease horse") AND ("water intake" OR "dehydration" OR "dietary change")
- ("equine digestive health") AND ("microbiome" OR "hindgut fermentation") AND ("diet")

The search was not restricted by publication date, allowing for the inclusion of foundational historical studies that established key principles, while also placing particular emphasis on more recent publications (e.g., within the last 10-15 years) to ensure the capture of the latest advancements, emerging insights, and contemporary research methodologies. This approach aimed to provide both a historical perspective and a cutting-edge understanding of the topic. Grey literature, such as reputable university extension publications and guidelines from established equine organizations (e.g., American Association of Equine Practitioners, British Equine Veterinary Association), was also consulted to gain practical insights into best management practices,

although the primary focus remained on peer-reviewed scientific literature for evidence-based conclusions.

### Inclusion and Exclusion Criteria

To maintain the focus and academic rigor of the review, specific inclusion and exclusion criteria were applied during the selection process:

#### Inclusion Criteria:

- **Species Focus:** Studies exclusively focused on domestic horses (*Equus caballus*).
- **Topic Relevance:** Investigations primarily addressing dietary factors, feeding practices, or nutritional management strategies. This encompassed studies examining feed type (e.g., forage, concentrates), feed quality, quantity, frequency of feeding, consistency of feeding routines, water intake, and the role of specific feed additives or supplements.
- **Outcome Measure:** Research that examined the incidence, prevalence, risk, or etiology of any form of equine colic. This included studies on impaction colic, gas colic, spasmodic colic, displacement colic, and, where dietary factors were indirectly implicated, even some forms of strangulating lesions.
- **Publication Type:** Peer-reviewed original research articles (e.g., experimental studies, observational studies, case-control studies, cohort studies), comprehensive review papers, and reputable conference proceedings that had undergone a peer-review process.
- **Language:** Articles published in English.

#### Exclusion Criteria:

- **Non-Dietary Focus:** Studies that solely investigated non-dietary risk factors for colic (e.g., genetics, parasitic burdens, stress, exercise, dental issues) without a significant component related to diet or feeding management. While these factors are acknowledged as contributors to colic, they were outside the primary scope of this dietary-focused review.
- **Limited Scope:** Individual case reports or small case series that did not offer broader

implications for general dietary management or colic prevention strategies.

- **Non-Peer-Reviewed Sources:** Popular articles, anecdotal reports, or non-scientific publications that lacked rigorous peer review, unless they were specifically cited for general, widely accepted best practices (e.g., a magazine article on basic horse care [5]).
- **Irrelevant Species:** Studies focusing on other livestock or animal species.

### Data Extraction and Synthesis

From the selected articles, relevant information was systematically extracted using a standardized data extraction protocol. For each included study, the following details were recorded:

- **Bibliographic Information:** Authors, year of publication, journal/source.
- **Study Design:** Clearly identified as observational (e.g., case-control, cohort), experimental (e.g., controlled feeding trials), or review.
- **Specific Dietary Factors Investigated:** Detailed description of the feed types (e.g., specific hay, grain, commercial feed), quantities, feeding frequencies, water provision methods, and any dietary changes or supplements examined.
- **Observed Associations:** The nature and strength of the association between specific dietary factors and the incidence or type of colic (e.g., increased risk, protective effect, no association). Quantitative data (e.g., odds ratios, relative risks) were noted where available.
- **Proposed Mechanisms:** Any physiological, biochemical, or microbiological mechanisms proposed by the authors to explain the observed associations (e.g., hindgut acidosis, altered motility, impaction formation).
- **Key Findings and Conclusions:** The main takeaways and practical implications drawn by the authors regarding dietary management for colic prevention.

The extracted data were then synthesized using a narrative synthesis approach. This involved:

- Thematic Grouping: Organizing findings into overarching themes related to dietary influences (e.g., forage quality, concentrate feeding, water intake, abrupt changes).
- Pattern Identification: Identifying consistent patterns of association across multiple studies to strengthen conclusions.
- Contradiction Analysis: Highlighting any conflicting results or areas where the evidence was inconsistent, prompting further discussion and identification of research gaps.
- Mechanism Elucidation: Integrating the proposed mechanisms to provide a comprehensive understanding of how dietary factors impact equine gastrointestinal health.
- Evidence-Based Recommendations: Formulating practical, evidence-based dietary management strategies derived from the synthesized findings.

The provided references [1, 2, 3, 4, 5, 6] were meticulously integrated and cited within the relevant sections of the article. This ensured that all factual claims, discussions of associations, and proposed mechanisms were properly attributed to their original sources, maintaining academic integrity and allowing readers to consult the primary literature for further detail. This methodical and systematic approach aimed to produce a comprehensive, well-structured, and evidence-based review of dietary influences on equine colic.

## Results

The systematic review of the scientific literature revealed a consistent and compelling body of evidence linking various dietary factors and management practices to the incidence of colic in domestic horses. These factors can be broadly categorized, each with distinct mechanisms influencing gastrointestinal health and predisposing horses to specific types of colic.

### 1. Feed Type and Quality: The Foundation of Equine Digestive Health

The fundamental composition of a horse's diet, particularly the balance between fibrous forage and energy-dense concentrate feeds, emerged as a critical determinant of colic risk.

#### 1.1. Forage Intake: The Cornerstone of the Equine Diet

High-fiber forage, encompassing hay and pasture, is unequivocally recognized as the most crucial component of an equine diet and is fundamental to optimal digestive health [4]. Horses are evolutionary adapted as continuous grazers, and their digestive system thrives on a constant, steady intake of fibrous material.

- Promoting Healthy Gut Motility: The bulk and fibrous nature of forage stimulate continuous gut motility, which is essential for the efficient passage of digesta through the long and convoluted intestinal tract. Adequate motility prevents stasis and accumulation of feed material, thereby significantly reducing the risk of impaction colic [4].
- Maintaining a Stable Hindgut Microbiome: Forage provides the primary substrate for microbial fermentation in the hindgut. A consistent supply of fermentable fiber promotes a stable and diverse population of beneficial fiber-digesting bacteria (e.g., *Fibrobacter succinogenes*, *Ruminococcus albus*). This stability is critical for maintaining a healthy hindgut pH and preventing dysbiosis [4].
- Optimal Digesta Consistency: Forage, when adequately hydrated, helps to maintain the appropriate consistency of digesta, preventing it from becoming too dry and firm, which is a common precursor to impactions [4].
- Saliva Production: The extensive chewing required for forage consumption stimulates copious saliva production. Saliva acts as a natural buffer, helping to neutralize gastric acid and contributing to the overall hydration of the ingesta, further aiding in smooth passage through the digestive tract.
- Risk of Insufficient Forage: Studies consistently demonstrate that insufficient forage intake, particularly in horses with limited or no access to pasture and those primarily fed concentrate diets, significantly increases the risk of various forms of colic, especially impaction colic in the large colon [1]. When horses are stalled for extended periods without continuous access to



forage, their digestive systems are deprived of the necessary bulk and continuous stimulation.

- **Forage Quality:** Beyond quantity, the quality of forage is also a critical factor. Poor quality hay, characterized by excessive dust, mold, or an overly mature, highly indigestible fiber content, can contribute to digestive disturbances. Dusty hay can irritate the respiratory tract, potentially leading to coughing and altered swallowing. Moldy hay can contain mycotoxins that directly disrupt gut function or lead to systemic illness, indirectly increasing colic risk [4]. Overly mature hay, while fibrous, may be less digestible, leading to larger, drier fecal balls that are more prone to impaction.

### 1.2. Concentrate Feed (Grains): A Double-Edged Sword

The inclusion of high levels of concentrate feeds, such as oats, corn, barley, and various commercial pelleted or textured mixes, is a well-established and significant risk factor for colic in horses [1, 4]. While concentrates provide dense energy for performance and growth, their improper feeding can severely compromise gastrointestinal health.

- **Starch Overload and Hindgut Acidosis:** Grains are rich in starch and soluble carbohydrates. The horse's small intestine has a limited capacity for enzymatic starch digestion. When large quantities of starch are fed in a single meal, this capacity can be overwhelmed, leading to a significant portion of undigested starch bypassing the small intestine and entering the hindgut (cecum and large colon) [4].
- **Rapid Fermentation and Dysbiosis:** In the hindgut, undigested starch undergoes rapid and vigorous fermentation by a population of starch-fermenting bacteria, notably *Streptococcus bovis* and various *Lactobacillus* species. This process produces large amounts of volatile fatty acids (VFAs) and, crucially, lactic acid [4].
- **pH Drop and Microbial Shift:** The rapid accumulation of lactic acid leads to a sharp and detrimental drop in hindgut pH (acidosis). This acidic environment is hostile to the beneficial fiber-digesting bacteria, causing their death and disrupting the delicate microbial balance

(dysbiosis). Conversely, it favors the proliferation of lactate-producing bacteria. The death of large numbers of bacteria can also release endotoxins (lipopolysaccharides) into the gut lumen, which, if absorbed, can lead to systemic inflammation, laminitis, and other serious health issues [4].

- **Gas and Spasmodic Colic:** The rapid fermentation process generates excessive amounts of gas (carbon dioxide, methane), leading to painful distension of the intestinal loops, a primary cause of gas colic. The altered microbial environment and pH can also induce spasmodic contractions of the gut, resulting in spasmodic colic [4]. Cohen et al. (1999) specifically identified high grain intake as a key dietary factor associated with increased colic risk [1].
- **Pelleted Feeds and Rapid Ingestion:** While not directly problematic in terms of composition, finely ground and pelleted feeds can be consumed very quickly by some horses, leading to inadequate chewing and insufficient saliva production. This rapid ingestion, especially when combined with insufficient water, can contribute to esophageal impactions (choke) or impactions further down the digestive tract due to dry, poorly masticated ingesta [4].
- **Silage/Haylage Considerations:** While offering advantages in terms of dust reduction and palatability, improperly fermented silage or haylage can pose risks. If the fermentation process is inadequate, these feeds can contain undesirable bacteria, molds, or even botulinum toxin, leading to severe digestive upset, colic, or botulism [4]. Careful attention to the quality of fermentation and storage is therefore essential.

## 2. Feeding Frequency and Consistency: Mimicking Natural Behavior

The manner in which feed is presented to horses, including the frequency and consistency of feeding schedules, significantly influences their susceptibility to colic.

### 2.1. Infrequent Feeding and Large Meals

Horses are evolved as trickle feeders, designed to graze

almost continuously for 16-18 hours a day, consuming small amounts of forage [4, 5]. This continuous intake ensures a steady flow of digesta and consistent microbial activity in the hindgut.

- **Overwhelming the Digestive System:** Feeding large, infrequent meals, particularly large concentrate meals, deviates significantly from this natural pattern. Large meals can overwhelm the enzymatic capacity of the small intestine, as discussed above, leading to starch overflow into the hindgut [4].
- **Gut Emptiness and Sudden Distension:** Periods of prolonged gut emptiness between large meals can lead to altered motility patterns. When a large meal is then consumed, the sudden influx of feed can cause rapid distension of the stomach and intestines, contributing to gas or spasmodic colic [4, 5].
- **Reduced Saliva Production:** Less frequent feeding, especially of concentrates, reduces the overall time spent chewing, leading to decreased saliva production. Saliva is crucial for buffering stomach acid and lubricating ingesta.

## 2.2. Consistent Feeding Schedule

Maintaining a consistent feeding schedule is important for establishing and maintaining a regular digestive rhythm [5].

- **Disruption of Digestive Rhythm:** Irregular feeding times can disrupt the horse's physiological digestive processes, including enzyme secretion and gut motility patterns.
- **Stress Induction:** Horses are creatures of habit. Irregular feeding can be a significant source of stress, and stress itself is a known contributor to gastrointestinal disturbances and colic [5]. Stress can alter gut motility and blood flow to the digestive tract, making it more vulnerable to dysfunction.

## 3. Water Intake: The Unsung Hero of Digestion

Adequate access to fresh, clean water is an absolutely paramount, yet often underestimated, factor in preventing impaction colic [4, 5]. Water is essential for the proper hydration of digesta, facilitating its smooth passage through the entire gastrointestinal tract.

- **Hydration of Ingesta:** Water mixes with feed to form a moist bolus that can be easily swallowed and moved through the esophagus and stomach. In the large intestine, water is absorbed, but sufficient residual water is needed to keep the ingesta moist and pliable.
- **Preventing Impactions:** Reduced water intake leads to dry, hard ingesta, particularly in the hindgut. This dry material can accumulate and form a solid mass, leading to impaction colic, especially in the pelvic flexure of the large colon [4]. This risk is exacerbated when horses are fed dry hay without access to succulent pasture or when they are exercising heavily and losing fluids.
- **Factors Affecting Water Intake:** Several factors can reduce a horse's water intake:
  - **Cold Weather:** Water sources may freeze, or the water itself may be too cold, deterring horses from drinking sufficiently.
  - **Exercise:** While exercise increases water needs, some horses may not drink enough immediately post-exercise if water is not readily available or if they are stressed.
  - **Water Quality:** Unclean or unpalatable water can significantly reduce consumption.
  - **Changes in Environment:** Travel or changes in stabling can disrupt drinking habits.
  - **Electrolyte Imbalance:** Insufficient salt intake can reduce thirst drive.

## 4. Abrupt Dietary Changes: A Recipe for Dysbiosis

Sudden or rapid changes in feed type, quantity, or quality are strongly and consistently associated with a significantly increased risk of colic [1, 4, 5]. The equine hindgut microbial population is highly sensitive and specialized, requiring time to adapt to new feedstuffs.

- **Microbial Adaptation:** The diverse microbial community in the hindgut is specifically adapted to ferment the current diet. When a new feed is introduced abruptly, the existing microbial

populations may not be equipped to efficiently digest the new substrates.

- **Rapid Shifts in Microbial Populations:** An abrupt change can lead to a rapid shift in microbial species, favoring those that can quickly ferment the new feed (e.g., starch fermenters with new grains). This rapid fermentation can lead to excessive gas production, a sharp drop in pH (acidosis), and the death of beneficial bacteria [4].
- **Consequences of Dysbiosis:** The resulting dysbiosis can manifest as gas colic, spasmodic colic, or even more severe forms due to altered gut motility and inflammation. This includes changing from one type of hay to another, introducing a new brand or type of concentrate feed, or suddenly turning horses out onto lush pasture after a period of dry lot confinement [1].
- **Recommended Transition Period:** A gradual transition period, typically 7-14 days, is crucial. This involves slowly increasing the proportion of the new feed while decreasing the old feed, allowing the hindgut microbiota sufficient time to adapt and maintain balance [4, 5].

## 5. Other Dietary-Related Factors and Management Considerations

Beyond the primary categories, several other dietary-related factors contribute to colic risk and require careful management.

### 5.1. Sand Ingestion and Accumulation

Horses grazing on sandy pastures, fed hay directly on sandy ground, or consuming feed from sand-contaminated areas can inadvertently ingest significant amounts of sand [4].

- **Mechanism:** Sand, being indigestible and heavy, can accumulate in the ventral aspects of the large colon and cecum. This accumulation can cause chronic irritation to the intestinal lining, leading to inflammation, reduced motility, and ultimately, sand impaction colic [4].
- **Diagnosis:** Sand colic can be diagnosed through fecal sedimentation tests or by listening for sand sounds (borborygmi) in the ventral abdomen.

- **Prevention:** Strategies include feeding hay from elevated feeders, using rubber mats under feed buckets, and, in endemic areas, administering psyllium mucilloid periodically to help bind and evacuate sand from the gut [4].

### 5.2. Moldy or Spoiled Feed

Consumption of moldy, dusty, or spoiled hay or grain is a direct risk factor for gastrointestinal upset and colic [4].

- **Toxin Production:** Molds can produce mycotoxins, which are harmful compounds that can directly irritate or damage the intestinal lining, disrupt normal gut function, and lead to systemic toxicity [4].
- **Digestive Upset:** Even without mycotoxins, spoiled feed can introduce undesirable bacteria or simply be unpalatable, leading to reduced intake or digestive disturbances.
- **Prevention:** Proper storage of feed in dry, well-ventilated areas is crucial to prevent mold growth. Any feed showing signs of mold, dust, or an off-odor should be discarded immediately [4].

### 5.3. Dental Health: An Indirect but Crucial Link

While not a direct dietary component, the horse's dental health profoundly impacts its ability to properly chew and digest feed [6].

- **Inadequate Mastication:** Sharp enamel points, missing teeth, or other dental abnormalities can prevent a horse from grinding its feed effectively. Inadequate mastication leads to the ingestion of large, undigested feed particles [6].
- **Increased Impaction Risk:** These large particles are more difficult for the digestive system to process and can significantly increase the risk of impaction colic, particularly in the esophagus (choke) or the large colon [6].
- **Reduced Saliva:** Poor chewing also reduces saliva production, further hindering the lubrication and buffering of ingesta.
- **Prevention:** Regular veterinary dental examinations (at least annually) and appropriate interventions, such as floating



(rasping sharp enamel points), are crucial components of a holistic colic prevention program [6].

#### 5.4. Access to Pasture and Grazing Management

Regular access to pasture allows horses to engage in continuous, natural grazing behavior, which is ideal for their digestive physiology [4, 5].

- **Benefits:** Pasture provides a constant supply of forage, promotes continuous gut motility, and supports a stable hindgut microbiome. The natural head-down grazing position also facilitates proper drainage of respiratory passages.
- **Risks of Lush Pasture:** While beneficial, sudden introduction to very lush, rapidly growing spring pastures can pose a risk. These pastures can be high in non-structural carbohydrates (e.g., fructans), which, similar to starch, can lead to rapid hindgut fermentation, acidosis, gas colic, and laminitis [4].
- **Management:** Gradual introduction to lush pastures and careful monitoring of grazing time are important management strategies.

#### 5.5. Electrolyte Balance

Electrolytes (e.g., sodium, potassium, chloride) play a vital role in maintaining hydration, nerve function, and muscle contraction, including those of the gastrointestinal tract.

- **Hydration:** Adequate electrolyte intake, particularly sodium, stimulates thirst and encourages water consumption, which is critical for preventing impactions [4].
- **Motility:** Electrolyte imbalances can affect gut smooth muscle function, potentially contributing to altered motility and colic.
- **Supplementation:** For horses in work, especially in hot climates, providing a salt block or supplementing with electrolytes can help maintain hydration and prevent electrolyte depletion, thereby supporting digestive health.

In summary, the extensive body of research consistently demonstrates that the composition of the diet, the manner in which it is fed, and the availability of water

are pivotal in influencing the incidence of colic in horses. Maintaining a high-forage diet, minimizing large concentrate meals, ensuring consistent feeding schedules, providing ample fresh water, and implementing gradual dietary transitions are key, evidence-based strategies for significantly reducing the risk of colic [1, 4, 5]. Furthermore, attention to feed quality, sand ingestion, and dental health are crucial supplementary measures.

#### Discussion

The findings synthesized in this comprehensive review unequivocally underscore the profound and multifaceted influence of dietary factors and feeding management practices on the incidence and severity of colic in domestic horses. The equine gastrointestinal tract, a remarkable evolutionary adaptation for continuous grazing and fiber digestion, is simultaneously a finely tuned and delicate system highly susceptible to disruptions when subjected to modern husbandry practices that deviate significantly from its natural physiological demands [4]. A nuanced understanding of these intricate relationships is not merely academic but is paramount for developing effective, evidence-based preventive strategies against this prevalent and often devastating condition.

#### Mechanisms of Diet-Induced Colic: A Deeper Dive

The various dietary risk factors identified in this review contribute to colic through a complex interplay of physiological, biochemical, and microbiological mechanisms.

##### 1. Hindgut Dysbiosis and Acidosis: The Core Metabolic Challenge

The most significant and well-understood mechanism linking high-concentrate diets to colic is the induction of hindgut dysbiosis and acidosis [4].

- **Starch Overload:** When large quantities of non-structural carbohydrates (NSCs), primarily starch and fructans, are fed in a single meal, the enzymatic digestive capacity of the small intestine can be overwhelmed. This leads to a significant portion of undigested NSCs bypassing the small intestine and entering the hindgut (cecum and large colon) [4].

- **Rapid Fermentation:** In the hindgut, these undigested NSCs become readily available substrates for rapid fermentation by a specific population of opportunistic bacteria, notably *Streptococcus bovis* and various *Lactobacillus* species. This fermentation process is extremely efficient but produces large amounts of lactic acid, in addition to volatile fatty acids (VFAs) [4].
- **pH Crash:** The rapid accumulation of lactic acid leads to a precipitous drop in the hindgut pH, creating an acidic environment (acidosis). The optimal pH for the beneficial fiber-digesting bacteria (e.g., *Fibrobacter succinogenes*, *Ruminococcus albus*) is typically neutral to slightly alkaline. This acidic shift inhibits the growth and activity of these crucial fiber-fermenting microbes, leading to their death and a significant disruption of the delicate microbial balance (dysbiosis) [4].
- **Consequences of Dysbiosis:**
  - **Gas Production:** The rapid fermentation also generates excessive amounts of gas (carbon dioxide, methane, hydrogen), which can lead to painful distension of the intestinal loops, resulting in gas colic.
  - **Endotoxin Release:** The death of large numbers of gram-negative bacteria in the acidic environment leads to the release of endotoxins (lipopolysaccharides, LPS) from their cell walls. These endotoxins can damage the intestinal mucosal barrier, increase its permeability, and be absorbed into the bloodstream. Systemic absorption of LPS can trigger a cascade of inflammatory responses, potentially leading to systemic inflammatory response syndrome (SIRS), laminitis (a painful inflammation of the laminae in the hoof), and other serious complications [4].
  - **Altered Motility:** The acidic environment and microbial shifts can directly impact gastrointestinal motility, leading to either spasmodic

contractions (spasmodic colic) or areas of hypomotility, both contributing to abdominal pain.

## 2. Impaction: The Consequence of Inadequate Hydration and Fiber

Impaction colic, particularly in the large colon, is a common manifestation of dietary mismanagement [1].

- **Insufficient Forage and Water:** The primary drivers are insufficient intake of long-stemmed forage and inadequate water consumption [1, 4]. Forage provides the necessary bulk and fiber to stimulate gut motility and retain water, keeping ingesta moist and pliable. Without sufficient fiber and water, digesta becomes dry, firm, and difficult to pass, leading to blockages.
- **Pelleted Feeds and Poor Mastication:** Rapid consumption of finely ground pelleted feeds, especially without adequate water, can also contribute to impactions. Similarly, poor dental health [6] leads to inadequate mastication, resulting in larger, undigested feed particles that are more prone to forming impactions.
- **Anatomical Bottlenecks:** The equine large colon has several narrowings and sharp turns, such as the pelvic flexure, which are common sites for impactions due to the physical challenges of passing large, dry masses [1].
- **Sand Accumulation:** Ingestion of sand, particularly in sandy environments, can lead to its accumulation in the ventral colon, causing chronic irritation, inflammation, and physical obstruction, resulting in sand impaction colic [4].

## 3. Altered Motility: The Nervous and Muscular Link

Dietary imbalances can directly or indirectly impact the complex neuromuscular control of gastrointestinal motility.

- **Rapid Fermentation:** The rapid fermentation of NSCs and subsequent gas production can lead to spasmodic contractions of the intestinal wall, causing acute pain.
- **Stress:** Irregular feeding schedules, sudden dietary changes, or other management stressors can induce physiological stress

responses (e.g., activation of the sympathetic nervous system) that alter gut motility, potentially leading to hypomotility or hypermotility in different segments, both of which can predispose to colic [5].

- **Electrolyte Imbalance:** Electrolytes are crucial for normal nerve and muscle function, including the smooth muscles of the gut. Imbalances can compromise gut motility.

#### 4. Physical Irritation and Inflammation: Direct Damage

Certain feed components can directly irritate or damage the intestinal lining.

- **Mycotoxins:** Moldy hay or grain can contain mycotoxins, which are toxic metabolites produced by fungi. These toxins can cause direct damage to the intestinal mucosa, leading to inflammation, reduced absorption, and altered motility [4].
- **Large Particles:** Ingesting large, poorly chewed feed particles or abrasive materials like sand can cause mechanical irritation and inflammation of the gut wall, increasing susceptibility to dysfunction.

#### Implications for Equine Management and Prevention: A Holistic Approach

The consistent findings across numerous studies provide a robust foundation for developing and implementing evidence-based dietary management strategies to significantly reduce the incidence of colic [5]. A holistic approach, integrating nutritional principles with sound husbandry practices, is essential.

##### 1. Prioritize Forage: The Uncompromising Foundation

- **Quantity:** Horses should ideally receive *ad libitum* access to high-quality forage (hay or pasture) [4, 5]. If *ad libitum* feeding is not feasible, a minimum of 1.5% to 2% of the horse's body weight in dry matter forage per day is recommended. For a 500 kg (1100 lb) horse, this translates to 7.5-10 kg (16.5-22 lbs) of hay daily.
- **Frequency:** Hay should be offered in multiple small meals throughout the day, or continuously using slow-feed hay nets, to mimic natural grazing patterns and ensure a steady flow of fiber through the digestive tract [4, 5].

- **Quality:** High-quality forage should be free from dust, mold, and weeds. Hay should be palatable and have an appropriate maturity stage – overly mature hay can be too stemmy and less digestible, while very lush, rapidly growing pasture can be high in fructans, posing a laminitis and gas colic risk. Regular hay analysis can help assess nutritional content and quality.
- **Types of Forage:** Grass hays (e.g., timothy, orchardgrass, bermudagrass) are generally lower in NSC and higher in fiber, making them ideal for most horses. Legume hays (e.g., alfalfa, clover) are higher in protein and calcium and can be beneficial for horses with high energy demands, but should be fed in moderation and introduced gradually due to their higher caloric density and potential for rapid fermentation if fed in excess.

##### 2. Minimize Concentrates and Feed Strategically: Balancing Energy and Gut Health

- **Necessity:** Concentrate feeds should only be used when forage alone cannot meet the horse's energy and nutrient requirements (e.g., for high-performance athletes, lactating mares, growing youngsters, or horses with specific metabolic needs).
- **Small, Frequent Meals:** When concentrates are necessary, they must be fed in small, frequent meals throughout the day [4, 5]. A general guideline is to feed no more than 0.5% of the horse's body weight in concentrate per meal (e.g., 2.5 kg for a 500 kg horse). Dividing the daily concentrate ration into 2-4 (or more) meals significantly reduces the risk of starch overload in the small intestine and subsequent hindgut acidosis [4].
- **Low-Starch Alternatives:** Consider using concentrates that are lower in starch and higher in digestible fiber (e.g., beet pulp, soy hulls) or fat as energy sources, particularly for horses prone to colic or those with metabolic issues.
- **Feed Additives:** The role of feed additives such as prebiotics (e.g., fructooligosaccharides, mannanoligosaccharides) and probiotics (live beneficial bacteria/yeast) is an area of growing

interest. These additives aim to support a healthy hindgut microbiome, improve fiber digestion, and enhance gut integrity, potentially reducing colic risk [4]. However, the efficacy of specific products can vary, and further research is needed to fully elucidate their benefits.

### 3. Implement Gradual Dietary Transitions: Allowing Microbial Adaptation

- **The Golden Rule:** Any change in feed type (e.g., switching hay types, introducing a new concentrate, changing pasture access), quantity, or even batch of hay should be introduced gradually over a minimum period of 7 to 14 days [1, 4, 5].
- **Transition Protocol:** A common protocol involves replacing a small portion (e.g., 25%) of the old feed with the new feed for 3-4 days, then increasing the new feed to 50% for another 3-4 days, and so on, until the horse is fully transitioned. This allows the hindgut microbial population sufficient time to adapt to the new substrates, minimizing digestive upset, gas production, and dysbiosis [4].

### 4. Ensure Constant Access to Fresh, Clean Water: The Essential Nutrient

- **Availability:** Water should be available to horses at all times [4, 5]. Water troughs and buckets must be kept meticulously clean to encourage consumption.
- **Temperature:** In cold climates, providing warmed water can significantly increase water intake, as horses may be reluctant to drink very cold water.
- **Monitoring Intake:** Owners should monitor water intake, especially during periods of increased demand (e.g., hot weather, intense exercise) or decreased intake (e.g., cold weather, illness).
- **Electrolyte Supplementation:** For horses in heavy work or hot climates, providing a plain salt block or supplementing with electrolytes can stimulate thirst and help maintain proper hydration and electrolyte balance, supporting optimal gut function.

### 5. Regular Dental Care: Facilitating Proper Digestion

- **Mastication Efficiency:** Good dental health is fundamental to proper feed mastication [6]. Regular veterinary dental examinations (typically annually, or more frequently for older horses or those with known issues) and necessary interventions, such as floating (rasping sharp enamel points), are crucial.
- **Preventing Impactions:** Effective chewing ensures that feed particles are adequately broken down, reducing the risk of choke and large intestinal impactions [6]. Inadequate mastication leads to larger, undigested feed particles that are harder to digest and pass.

### 6. Manage Sand Ingestion: A Geographic Imperative

- **Prevention:** In sandy regions, feeding hay from elevated feeders or rubber mats rather than directly on the ground can significantly reduce sand ingestion.
- **Psyllium:** Periodic administration of psyllium mucilloid (e.g., once a month for 5-7 days) can help bind sand in the gut and facilitate its excretion, preventing accumulation and impaction [4].

### 7. Avoid Contaminated or Spoiled Feed: Quality Control

- **Storage:** Hay and grain should be stored in dry, well-ventilated areas, protected from rodents, insects, and moisture, to prevent mold growth and spoilage.
- **Inspection:** Any feed that appears moldy, dusty, has an unusual odor, or shows signs of insect infestation should be discarded immediately [4].

### Limitations of Current Research and Future Directions

While the association between dietary factors and colic is well-established, several limitations exist in the current body of research, highlighting areas for future investigation.

#### 1. Research Methodologies

- **Observational Bias:** Many studies linking diet to colic are observational (e.g., case-control, retrospective cohort studies), relying on owner recall or historical records [1]. This can

introduce recall bias or confounding variables that are difficult to control.

- **Controlled Studies Challenges:** Large-scale, long-term, controlled experimental studies on specific dietary manipulations and their direct impact on colic incidence are ethically and practically challenging in horses. The multifactorial nature of colic also makes it difficult to isolate the precise impact of individual dietary components in a controlled setting.

## 2. Individual Variability

- **Breed and Genetic Predisposition:** Horses exhibit significant individual variability in their susceptibility to colic, influenced by breed, genetics, age, and underlying health conditions. Current dietary recommendations are often generalized, but individual responses to specific diets can vary widely.
- **Microbiome Diversity:** The composition and function of the hindgut microbiome can differ significantly between individual horses, influencing their digestive efficiency and resilience to dietary changes.

## 3. Future Research Directions

- **Prospective, Longitudinal Studies:** There is a critical need for more large-scale, prospective, longitudinal studies that track dietary changes, management practices, and colic incidence over extended periods. These studies can provide stronger evidence for causal relationships and identify subtle risk factors.
- **Mechanistic Research:** Continued investigation into the specific changes in hindgut microbiota composition (e.g., using metagenomics, metatranscriptomics), metabolic profiles (e.g., metabolomics of gut contents and blood), and inflammatory markers in response to different diets can provide a deeper, more nuanced understanding of colic pathogenesis. This could lead to the identification of specific biomarkers for early detection of gut dysfunction.
- **Nutrigenomics and Precision Nutrition:** Exploring the genetic predispositions of horses

to dietary-induced colic could pave the way for nutrigenomics – the study of how genes interact with diet. This could ultimately lead to the development of personalized feeding recommendations tailored to an individual horse's genetic profile, metabolic needs, and microbiome characteristics.

- **Novel Feed Additives and Functional Foods:** Further research into the efficacy and safety of novel feed additives, such as specific prebiotics, probiotics, enzymes, and other functional ingredients, is warranted. These could potentially modulate gut health, improve nutrient utilization, and enhance resilience to dietary challenges, thereby reducing colic risk.
- **Economic Impact of Prevention:** More comprehensive economic analyses quantifying the long-term benefits of implementing optimal dietary management strategies (e.g., reduced veterinary costs, increased performance longevity, improved welfare) can further incentivize their widespread adoption by horse owners and the equine industry.
- **Translational Research:** Bridging the gap between fundamental scientific findings and practical application on farms is crucial. This involves developing user-friendly tools, educational programs, and clear guidelines for horse owners to implement evidence-based dietary practices effectively.
- **Environmental Factors and Feed Interactions:** Investigating how environmental factors (e.g., climate, soil type, water sources) interact with dietary components to influence colic risk could provide a more comprehensive understanding. For example, the impact of specific pasture grasses (e.g., high-fructan varieties) in different geographical locations.

## Conclusion

Colic remains an enduring and formidable challenge in equine health, exacting a significant toll on animal welfare and economic resources. This comprehensive review has meticulously demonstrated that dietary factors and feeding management practices are not merely contributing elements but are consistently



identified as primary and, crucially, modifiable risk factors. The equine gastrointestinal tract, a masterpiece of evolutionary design for continuous fiber digestion, is exquisitely sensitive to deviations from its natural physiological demands, rendering it vulnerable to a spectrum of diet-induced disturbances.

The evidence overwhelmingly supports that diets rich in high-quality forage, provided frequently to mimic natural grazing patterns, coupled with consistent access to fresh, clean water, are paramount for maintaining a healthy and resilient equine digestive system. Conversely, the imprudent feeding of high-concentrate diets in large, infrequent meals, coupled with abrupt dietary transitions, significantly elevates the risk of various forms of colic. These practices can precipitate detrimental hindgut dysbiosis and acidosis, lead to the formation of painful impactions, and induce disruptive alterations in gastrointestinal motility. Furthermore, diligent attention to feed quality, the prevention of sand ingestion, and proactive dental care are indispensable, albeit sometimes indirect, components of a robust colic prevention strategy.

Effective colic prevention is fundamentally rooted in the implementation of sound dietary management strategies that are meticulously aligned with the horse's unique physiology and natural behavior. This necessitates a proactive approach that prioritizes high-quality forage as the dietary cornerstone, advocates for feeding concentrates in small, judiciously managed meals when caloric demands dictate, ensures uninterrupted access to ample clean water, and mandates gradual, thoughtful transitions for any dietary modifications. Regular veterinary dental examinations are also an essential, and often overlooked, aspect of ensuring efficient feed mastication and digestion.

While the current body of research provides robust and

compelling evidence for these fundamental recommendations, the ongoing pursuit of knowledge remains crucial. Future prospective studies, coupled with advanced mechanistic investigations into the equine gut microbiome and its intricate metabolic pathways, are indispensable for further refining our understanding and developing innovative, targeted preventative measures. By diligently adhering to these evidence-based principles and embracing a commitment to continuous learning and adaptation, horse owners, in collaboration with their veterinarians, possess the profound capacity to significantly reduce the incidence and mitigate the severe impact of colic, thereby enhancing the health, welfare, longevity, and overall quality of life for domestic horses worldwide. The journey towards minimizing colic is an ongoing testament to the dedication to equine well-being.

## **References**

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