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Modern Equine Nutrition: Forage-Centred Feeding, Gut Microbiome and Nutritional Strategies for Health, Performance and Welfare: Review Article

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ABSTRACT:

Equine nutrition must accommodate the digestive physiology of horses, which are hindgut-fermenting herbivores adapted to consume fibrous forage over many hours. Forage quality, feeding pattern, exercise, age, body condition, reproductive state and health all affect nutrient requirements and practical ration design. Concentrate-rich diets or abrupt dietary changes may disrupt normal digestive function, while inadequate forage access can compromise feeding behaviour and welfare. This review examines forage assessment and conservation, energy and protein supply, mineral balance, hindgut microbiome relationships, functional supplements and nutrition management across maintenance, growth, reproduction and performance. Evidence on yeast products and other supplements is promising in selected settings, but responses are variable and should not displace the fundamentals of forage quality, clean water, gradual transitions and appropriate body condition. Recent quantitative work has also highlighted that forage intake and digestibility depend on feed composition and horse characteristics, reinforcing the need for accurate ration assessment. The review considers practical implications for Indian equids, including working horses, ponies, donkeys and mules, where feed availability, workload and veterinary access may differ from sport-horse systems. Future research should link diet and microbiome measurements to clinical outcomes, improve locally relevant forage databases and assess the cost-effectiveness of feeding interventions. An individualized, evidence-based forage-centred approach remains the most reliable foundation for equine health, performance and welfare.

Keywords: Equine nutrition; forage; hindgut fermentation; gut microbiome; feeding behaviour; performance; welfare; India

Review scope: This narrative review synthesizes selected peer-reviewed literature and authoritative reference works relevant to the topic. It is not presented as a systematic review; claims and recommendations should be checked against the cited original sources before journal submission.

1. Introduction

Horses and other equids have evolved as grazing herbivores that ingest fibrous plant material over extended periods. Their digestive system relies on microbial fermentation in the caecum and colon, making forage quantity, quality and feeding pattern central to nutritional management. Modern management frequently includes stabling, limited pasture access, concentrated feeds and exercise schedules that differ from natural grazing. These changes can be useful for particular workloads, but they also create nutritional and behavioural challenges when the diet is not planned around equine physiology (Harris et al., 2017).

A sound review of equine nutrition must therefore consider not only energy and nutrient totals but also the form, timing and hygiene of feeds, as well as age, workload, body condition and health. Recent quantitative research on voluntary forage intake and nutrient digestibility further emphasizes the importance of feed characteristics and animal-level variation (Webster et al., 2025).

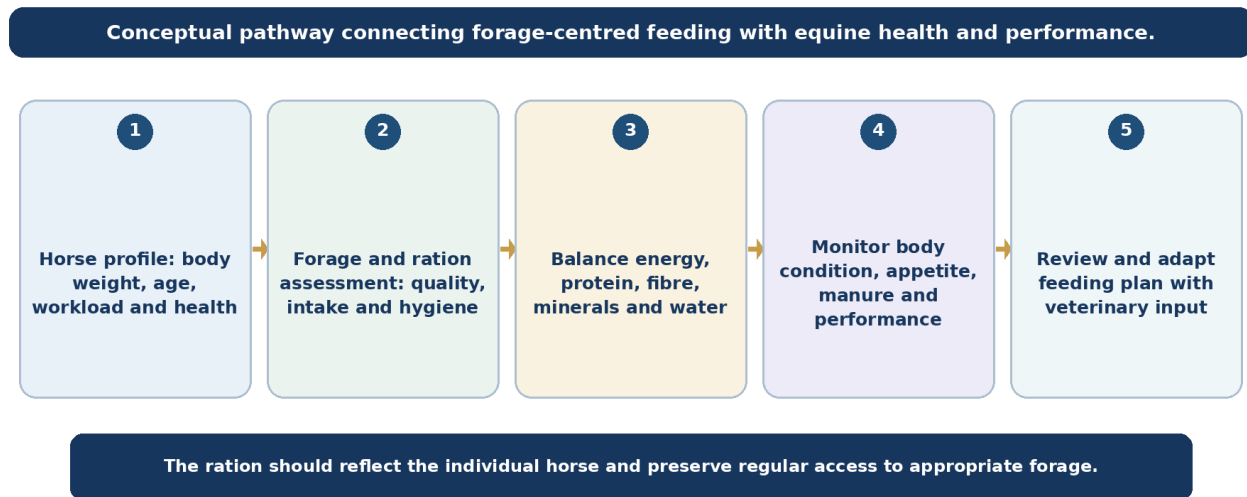


Fig. 1. Conceptual pathway connecting forage-centred feeding with equine health and performance.

Figure 1 illustrates the conceptual framework for this review. The arrows represent a management sequence and feedback relationship, not a claim that all effects occur uniformly across species or production systems.

2. Forage as the foundation of the diet

2.1 Species, maturity and nutritive value

Pasture grasses, hay, haylage and other conserved forages differ in fibre, protein, digestible energy, minerals and non-structural carbohydrates. Plant species and stage of maturity influence stem-to-leaf ratio and digestibility, while cutting, drying and storage affect quality and hygiene. Forage analysis can help identify whether the diet requires a balancer, extra energy or a specific mineral correction. Visual appearance alone does not reliably quantify nutrient composition or hygienic risk.

2.2 Intake, chewing and feeding rhythm

Forage supports chewing and saliva production and provides fermentable substrate to the hindgut. Feeding management should allow sufficient total forage intake while avoiding prolonged unintended gaps, especially in horses prone to gastric discomfort or stereotypic behaviour. The required amount depends on body weight, forage quality, workload and metabolic status; horses prone to obesity may need controlled, carefully planned forage access rather than unlimited high-energy pasture. Intake prediction models can assist ration design, but they remain estimates and should be checked against body-condition trends and actual refusals (Webster et al., 2024; Lamanna et al., 2025).

2.3 Conservation and hygienic quality

Hay and haylage can provide a stable feed supply when pasture is unavailable, but conservation quality matters. Excessive moisture, mould, dust, soil contamination and poor storage may affect palatability and respiratory or digestive health. Feed should be inspected at purchase and during storage, and representative samples can be analysed where uncertainty affects ration decisions. Soaking or steaming may be appropriate for particular horses or forage problems, but methods differ in their effects on nutrients and hygiene; advice should match the specific objective rather than relying on a single universal procedure (Harris et al., 2017).

Table 1. Forage characteristics that influence equine ration design.

Factor	Nutritional significance	Practical assessment	Management response
Maturity and species	Influence fibre, digestibility and energy	Visual inspection plus laboratory analysis	Select forage to match workload and body condition
Moisture and preservation	Affect storage stability and hygiene	Dry matter, odour, visible mould and storage history	Store protected; discard spoiled material

Factor	Nutritional significance	Practical assessment	Management response
Fibre and non-structural carbohydrates	Influence hindgut substrate and metabolic risk	Fibre fractions and sugar/starch where indicated	Adjust forage/concentrate mix to clinical needs
Intake and feeding time	Determine total nutrient supply and behaviour	Estimate intake and observe feeding pattern	Avoid long unintended forage gaps where feasible

3. Energy, protein and micronutrient balance

Energy supply must reflect maintenance, growth, pregnancy, lactation, work intensity and environmental exposure. For many horses in light work, suitable forage can cover much of the requirement; harder-working horses or animals that struggle to maintain condition may need additional energy sources. High-starch concentrates should not be used as a substitute for evaluating forage, workload and feeding frequency. Fibre-based energy sources or fat may be useful in selected diets, but the total ration still requires balance.

Protein adequacy depends on both quantity and amino-acid quality, particularly in growing animals, pregnant mares and horses undergoing intensive exercise. Minerals such as calcium, phosphorus, copper, zinc, selenium and iodine have essential but dose-dependent roles. A ration containing several fortified feeds can unintentionally duplicate nutrients. The complete diet—including forage, concentrate, balancer, salt and supplements—should be assessed together. Nutrient requirement tables are useful starting points, but practical decisions require adjustment for individual condition and feed analysis (NRC, 2007).

4. Hindgut fermentation, microbiome and dietary transitions

4.1 Microbial fermentation and host function

The equine hindgut microbiome helps break down structural carbohydrates and produces short-chain fatty acids that contribute to energy supply. Microbial communities interact with gut motility, mucosal function and host metabolism. Diet can influence community composition, but microbiome differences are not automatically indicators of disease or health. Studies that measure only faecal microbial profiles cannot fully describe all regions of the gastrointestinal tract, and causal interpretation requires controlled feeding data alongside clinical outcomes (Chaucheyras-Durand et al., 2022).

4.2 Abrupt changes and digestive risk

Rapid changes in forage type, pasture access, concentrate quantity or feeding schedule can alter hindgut fermentation. Diet transitions should generally be gradual, with observation of appetite, faecal consistency, manure output and behaviour. Excessive starch that escapes digestion in the small intestine may reach the hindgut and change fermentation patterns. Poor-quality forage and inconsistent feeding also reduce the predictability of nutrient intake. A stable routine and appropriately formulated forage-based diet remain primary risk-management tools.

4.3 Functional microbial products

Live yeast and related microbial products have been investigated for their potential to influence fibre digestibility, fermentation and faecal microbial patterns. An updated review described possible applications while noting that results vary by product, diet and study endpoint (Perricone et al., 2022). Microbiome-targeted products should therefore be chosen according to a specific need and supported by equine data. They should not be presented as proven prevention or treatment for colic, ulcers or other clinical disorders.

5. Nutritional management by physiological stage and workload

Growing horses need a balanced supply of energy, quality protein and minerals to support development without encouraging overly rapid or imbalanced growth. Pregnant mares have changing requirements, with particularly important nutritional adjustments in late gestation and lactation. Breeding stallions require attention to condition and workload, while senior horses may need adaptations related to dental function, reduced intake or chronic disease. Working equids such as ponies, donkeys and mules need rations that reflect actual workload, body size, forage access and local management rather than assumptions derived only from racing or sport horses.

Performance diets should be built around the expected duration and intensity of work, body condition, forage quality, hydration and recovery. A feeding programme can be evaluated through weight trends, appetite, work output, recovery, manure, behaviour and veterinary outcomes. When performance declines or weight changes unexpectedly, nutrition is one possible contributor, but pain, dental disease, parasitism and other medical causes should be considered by a veterinarian.

Table 2. Main feeding priorities for common equine categories.

Category	Primary nutrition focus	Monitoring indicators	Important caution
Maintenance / leisure	Forage, suitable body condition and balanced minerals	Weight trend and body condition score	Avoid energy surplus in easy keepers
Growth	Balanced energy, quality protein and minerals	Growth pattern, skeletal development	Avoid unbalanced supplementation
Performance	Workload-matched energy, water and electrolytes	Work, recovery, sweat loss and appetite	Do not rely on high-starch meals as the only energy strategy
Pregnant / lactating mare	Stage-specific energy, protein and mineral supply	Body condition, foal growth and milk support	Requirements change sharply around foaling and lactation
Senior horse	Dental access, digestibility and adequate intake	Chewing, faecal quality and weight	Investigate weight loss rather than assuming age alone

6. Supplements and functional nutrition

Supplements can correct a documented nutrient gap or serve a defined function, but they should not replace forage assessment or complete-ration formulation. Electrolytes may be useful after prolonged sweating, yet water remains essential and the need depends on work, temperature and sweat loss. Fat sources may increase energy density with less starch, whereas vitamin–mineral balancers can address gaps when forage is the main feed. The most defensible supplement decisions identify an objective, check the product composition and assess the response over time.

Claims involving probiotics, botanical extracts or gastric-health products require product-specific evidence. Active-compound composition can vary, and some products may interact with medications or competition rules. Supplementation should be especially cautious in horses with metabolic disorders, recurrent gastrointestinal signs or other medical conditions. A veterinarian or equine nutritionist can help determine whether the intended benefit is plausible and whether it is worth the cost.

Table 3. Selected equine supplements: purpose and evidence considerations.

Supplement class	Common rationale	Evidence / interpretation	Caution
Live yeast / microbial products	Support fibre digestion or microbial stability	Responses vary with diet and product	Cannot compensate for unsuitable forage or abrupt transitions
Electrolytes	Replace sweat-associated losses after work	Need depends on duration, heat and sweat loss	Provide adequate water and avoid indiscriminate dosing
Oil / fat sources	Increase dietary energy with lower starch contribution	Useful for selected workload and metabolic contexts	Introduce gradually; maintain overall balance
Vitamin–mineral balancers	Correct gaps in forage-based diets	Useful when ration analysis identifies shortfalls	Avoid duplicate supplements and excesses
Proposed gut-health products	Support gastrointestinal function	Product-specific evidence remains variable	Review ingredients and consult a veterinarian when disease is suspected

7. Common nutritional risks and preventive management

7.1 Colic and feeding management

Colic is a clinical syndrome with multiple causes; it should not be attributed to a single ingredient without examination. Dietary risk reduction includes appropriate forage, clean water, gradual feed changes, consistent exercise and avoidance of large, poorly matched concentrate meals. Any persistent or severe abdominal pain, loss of appetite or abrupt change in manure requires prompt veterinary attention. Nutrition supports prevention and recovery planning but is not a substitute for diagnosis.

7.2 Obesity, insulin dysregulation and laminitis risk

Excess energy intake relative to energy expenditure can lead to obesity and metabolic risk. Pasture sugars and concentrate starch may need to be considered in susceptible horses, but restriction should preserve adequate fibre and nutrient balance. Body-condition scoring and a realistic weight trend help evaluate whether a plan is working. Horses with suspected insulin dysregulation or laminitis require veterinary management and an individualized diet; generalized online feeding advice may be unsafe for such cases. These principles are consistent with the ECEIM consensus recommendations for equine metabolic syndrome, which emphasize individualized assessment and management rather than one universal diet (Durham et al., 2019).

7.3 Gastric health and feeding behaviour

Horses naturally spend substantial time foraging, and prolonged forage deprivation can be inconsistent with normal feeding behaviour. A forage-centred routine, appropriate meal sizes and workload-appropriate feeding are important management considerations. Clinical signs such as appetite changes, poor performance or recurrent discomfort are non-specific and need veterinary evaluation before supplements are selected. Nutritional management should support normal behaviour as well as measured performance.

8. Hydration, heat and the Indian equine context

Hot environments can increase water loss and the need for careful exercise planning, shade and recovery. Working horses, donkeys and mules may experience long working hours and variable access to quality forage. Locally available grasses, crop residues and by-products may form part of their feeding systems, but their nutrient value and safety vary; low-quality residues may require supplementation and should not be assumed to meet all requirements. Clean water, adequate salt where appropriate, access to shade and monitoring of body condition are practical priorities.

Indian equids span sport, racing, ceremonial, transport, tourism and smallholder work settings. Nutrition programmes should distinguish these uses and account for body size, workload, season, access to grazing and feed affordability. Local forage libraries, training for owners and veterinary outreach could improve feeding decisions. Region-specific studies are needed because management practices and feed supplies differ from those in studies of stabled sport horses in Europe or North America.

9. Precision and data-informed equine nutrition

Precision equine nutrition can use body-weight estimates, body-condition scoring, weighed feed records, forage analysis, workload data and clinical history to refine rations. Wearable sensors may record activity or exercise, and digital tools can help follow trends across weeks. Nevertheless, sensor output must be validated in the intended setting and should not be used as a substitute for observing the horse. Intake remains difficult to measure where animals share pasture or forage racks, and feed composition can change between batches.

A practical feedback cycle starts by describing the horse and workload, testing or estimating the ration, setting a measurable goal and reviewing the response. Changes may target energy density, forage type, feeding frequency, water provision or specific supplements. The response should be documented and the plan changed if the expected benefit does not occur. Digital tools are most useful when they make records easier to interpret and support decisions by the owner, nutritionist and veterinarian.

Table 4. Practical indicators for individualized equine feeding.

Indicator	Why it matters	Method / record	Limitation
Body weight and condition	Tracks energy balance	Scale, weight tape, body-condition scoring	Tapes are estimates, not exact weights
Forage intake and quality	Determines nutrient delivery	Weigh feed offered/refused; forage analysis	Group housing complicates individual intake

Indicator	Why it matters	Method / record	Limitation
Feeding behaviour	Shows access and routine	Time budgets, observation or validated sensors	Behaviour varies with housing and individuals
Clinical and work records	Links feeding to outcomes	Manure, appetite, workload, recovery, veterinary history	Associations do not automatically establish causation

10. Research gaps and future directions

Research priorities include improved prediction of voluntary forage intake, evaluation of different forage species and preservation methods, microbiome studies linked to clinical outcomes, and trials of supplements using common endpoints. Indian studies should characterize locally used forages and by-products, assess the diets of working equids and compare feasible feeding interventions under farm conditions. Longer studies should include welfare, cost and durability of response—not only short-term digestibility or microbial measurements.

11. Quantifying forage intake and constructing a balanced ration

11.1 Forage analysis before supplement selection

A forage-centred programme begins with the material the horse actually consumes. Visual inspection can detect dust, mould, coarse stems, weeds or soil contamination, but it cannot reliably determine digestible energy, protein, minerals or non-structural carbohydrate concentration. Laboratory analysis gives a more useful basis for ration decisions, particularly for horses with obesity, insulin dysregulation, recurrent laminitis, poor performance or unusually high nutrient demand. Sampling should represent the batch, not only the most attractive handful. Hay from different fields, harvest dates or storage conditions should not automatically be treated as nutritionally equivalent (NRC, 2007; Harris et al., 2017).

Forage reports require interpretation. Dry-matter concentration determines how much feed is delivered on an as-fed basis; crude protein does not alone establish amino-acid adequacy; neutral detergent fibre provides information on structural material but does not fully predict voluntary intake; and water-soluble or ethanol-soluble carbohydrate measurements need to be interpreted using the laboratory method. The analysis should be linked to the specific clinical or production question. A single number rarely justifies a blanket recommendation for every horse in a stable.

11.2 Estimating intake and avoiding hidden ration errors

Voluntary forage intake can differ with palatability, body size, access, forage type, workload, dental condition, competition and management. A horse with continuous access to hay may consume more than assumed, while another may be displaced by stablemates or have difficulty chewing coarse forage. Weighing offered forage and refusals for several representative days can improve the estimate. Estimates remain imperfect because hay can be scattered or contaminated and pasture intake is difficult to measure directly, but even a reasonable record is usually superior to counting flakes or scoops without knowing their weight.

Ration calculations should separate dry matter from as-fed weight and include all feeds, supplements, treats and pasture. Commercial feeds vary in energy density and ingredient composition, so label feeding directions should be interpreted as starting guidance rather than a replacement for a whole-ration assessment. The goal is to identify a true shortfall or excess before purchasing a supplement. An energy deficit may call for more suitable forage or a carefully selected energy source; a mineral imbalance may require a balanced vitamin-mineral ration; a low body condition score may also demand investigation of dental, gastrointestinal or systemic disease.

11.3 Feed transitions and management records

Diet changes should be gradual because the hindgut microbial community adapts to its substrate. Changes in pasture access, forage species, concentrate amount, oil addition or supplement use can alter fermentation and nutrient intake. A transition plan should state what changes, when the change occurs, how rapidly it progresses and what will be monitored. Manure consistency, appetite, water intake, attitude, body condition and performance are useful observations, although none alone diagnoses a specific disorder. For a horse with a history of colic or laminitis, a veterinarian should help design transitions and define warning signs requiring immediate assessment.

A concise ration record should include the identity and batch of forage, measured daily quantity, feed label or analysis, supplement inclusion, turnout duration, exercise, medications and notable health events. Such records make it easier to interpret a decline in weight or performance and to determine whether a change in feed coincided with the problem. Recording only the brand name of a feed is insufficient when ingredients, batches and formulations can change. Good documentation also prevents accidental duplication of mineral or vitamin supplementation across multiple products.

12. Nutritional risk management for common equine disorders

12.1 Colic and gastrointestinal disturbance

Colic is a clinical syndrome with many causes, not one nutritional disease. Feeding-related risk can include abrupt diet changes, poor-quality forage, inadequate water, large starch-rich meals, restricted movement and management patterns that disrupt usual intake. A horse showing persistent pawing, rolling, sweating, repeated lying down, reduced manure output or other signs of abdominal pain needs prompt veterinary attention; a feeding article cannot substitute for diagnosis. Once a cause is identified and the horse is stable, ration planning can support recovery by considering water, forage form, meal size, digestibility and gradual reintroduction of feed.

For post-colic nutrition, the appropriate plan depends on the diagnosis, surgery status, intestinal function, pain management and risk of recurrence. The 2026 scoping review by Danese et al. found that the available literature was heterogeneous, but described support for timely, carefully managed enteral feeding when clinically indicated and for forage-centred, lower-starch approaches in relevant cases. This finding should not be turned into a universal schedule: horses with ileus, obstruction, severe intestinal damage or other complications may require a different plan under veterinary supervision. The central lesson is that nutrition must be coordinated with clinical management rather than prescribed in isolation.

12.2 Obesity, insulin dysregulation and laminitis risk

Overweight horses and ponies can accumulate excess adipose tissue and develop insulin dysregulation, increasing concern about laminitis in susceptible animals. Nutritional management often involves measured forage, appropriate energy restriction, safe exercise and veterinary assessment. Severe or prolonged restriction can cause distress and may create other nutrient inadequacies; therefore, weight loss should be planned and monitored rather than imposed abruptly. Forage testing can help identify high-sugar sources, while slow-feeding devices and multiple small forage offerings may increase feeding time, if used safely and hygienically.

Non-structural carbohydrate is not a single universal risk threshold. The response depends on the horse's metabolic status, feed composition, meal size, exercise and individual susceptibility. Recommendations need to specify the analytical fraction, basis of measurement and rationale. A feed with lower starch may still deliver substantial calories if fed in excess, and "natural" or grain-free products are not automatically appropriate. A complete nutritional assessment should cover protein, minerals, vitamins, essential fatty acids and total energy, not only sugar. Horses with laminitis or marked insulin dysregulation should be managed with the attending veterinarian. (Durham et al., 2019).

12.3 Gastric health, dental function and chronic undernutrition

Feeding behaviour and forage access influence gastric conditions because horses are adapted for prolonged consumption of fibrous feeds. Long gaps without forage, large concentrate meals, stress, travel and exercise patterns may interact with gastric disease risk. Clinical signs such as poor appetite, girthiness, altered behaviour or poor performance are nonspecific; a diagnosis may require veterinary examination. Nutritional decisions should follow diagnosis and consider forage access, meal distribution, concentrate starch, exercise schedule and stress reduction rather than relying on a single supplement marketed for gastric support.

Dental disease can reduce effective feed intake even where feed is available. Older horses may drop quids, chew slowly, lose weight or avoid long-stem forage. Management may require forage alternatives with suitable particle length or soaked feeds, while ensuring the ration remains nutritionally complete. Chronic weight loss also warrants evaluation for parasitism, endocrine disease, chronic pain and other disorders. Senior status alone does not automatically mean that a horse needs a high-energy commercial feed; diet form and nutrient density should reflect actual chewing ability, body condition, activity and medical status.

13. Individualized feeding by life stage and workload

13.1 Growth and skeletal development

Growing horses require balanced energy, high-quality protein and appropriate minerals to develop muscle, bone and connective tissue. Both inadequate supply and imbalanced supply can be harmful. Excessive energy intake may promote overly rapid growth or obesity, while inappropriate calcium-to-phosphorus balance or insufficient trace nutrients may impair development. Growth should be assessed over time rather than by one body weight. Breeding, genetics, expected mature size, exercise, pasture quality and ration composition interact; therefore, a ration designed for one age or breed cannot simply be applied to every young horse.

Foals and weanlings experience major nutritional transitions, and management should minimize avoidable stress while maintaining access to suitable forage and a balanced ration. Where pasture or dam's milk cannot supply the requirement, a formulated feed designed for growth may be appropriate, but its use should consider total intake and the mineral contribution from all sources. Over-supplementing selected minerals is not a reliable way to improve skeletal quality. Longitudinal growth records and veterinary review are more useful than reacting to a single measurement or marketing claim.

13.2 Pregnancy, lactation and breeding animals

Mare requirements change across gestation and rise substantially during lactation. The amount of concentrate necessary depends on forage quality, body condition, milk production, age and other physiological demands. A mare that is excessively thin or obese should be assessed before breeding where possible, because body reserves influence reproductive management. Mineral and vitamin adequacy is particularly important when the ration relies on home-grown forage with variable composition. Supplementation should close identified gaps rather than add multiple overlapping products. Stallions and breeding animals need sufficient energy and micronutrients for body condition and reproductive function, but evidence does not support treating high supplement levels as a substitute for overall health and sound breeding management. Nutrition should be considered alongside exercise, disease prevention, parasite control and veterinary reproductive assessment. During lactation, water access and forage availability are essential; sudden reductions in intake require investigation. Ration changes should be planned around foaling and management routines, with attention to the foal's access to milk and the mare's clinical condition.

13.3 Performance horses, recovery and electrolyte balance

Workload varies from light leisure riding to endurance, racing, eventing and other high-intensity activities. Energy strategy should reflect duration, intensity, fitness and recovery, not the category label alone. Forage remains important, while additional energy sources may be selected according to workload and gastrointestinal tolerance. Horses that sweat heavily can lose water and electrolytes, particularly sodium and chloride, but supplementation needs to reflect climate, sweat loss, water intake, feed content and work conditions. Concentrated electrolyte products without adequate water access can be inappropriate.

Performance evaluation should include body condition, body weight, appetite, recovery, workload completion, hydration status and clinical signs rather than relying solely on race time or a subjective impression of energy. Excess dietary energy can result in unwanted excitability or weight gain; inadequate energy can impair recovery and body condition. Any supplement intended to alter performance or recovery should be evaluated for composition, evidence, dose and competition rules. Horses with cardiac, renal or other medical conditions require professional advice before electrolyte or concentrated supplement programmes are changed.

14. Data-informed monitoring and the Indian equine context

14.1 Low-cost monitoring before advanced technology

A useful precision-feeding record can be assembled without specialist sensors. Repeated body-weight estimates, body-condition scoring, feed offered and refused, forage analysis, workload, water access and clinical observations can show trends that one-time assessments miss. Girth-based weight tapes can be imprecise, particularly across body types; the same method should be used consistently and interpreted as a trend rather than an exact value. Photographs taken under consistent posture and lighting can support body-condition review, but they do not replace hands-on assessment. Wearable activity monitors, automated scales and camera systems may improve monitoring in larger training yards or research centres. Their output depends on fitting, calibration, horse behaviour, environment and the algorithm used. A device may detect a change in activity without explaining whether the cause is feed, pain, weather, transport or social change. Data should trigger a structured investigation, not an automatic ration change. In equine nutrition, a practical closed loop links a measured problem to a specific intervention and then tracks a defined outcome over time.

14.2 Hot-weather management and transport

Hot and humid conditions increase the importance of water, shade, ventilation, suitable work scheduling and recovery management. Heat load can reduce appetite and increase fluid losses, while travel may change access to forage and water and disrupt normal routines. Nutrition alone cannot resolve heat stress: environmental management, rest and clinical monitoring are fundamental. For horses travelling or working in hot climates, management plans should account for duration, acclimation, workload, water availability, sweat loss and any relevant veterinary conditions. Water consumption and recovery observations should be recorded when practical.

Transport also introduces changes in meal timing, forage availability, stress and movement. Abruptly changing the feed immediately before or after transport can compound the disturbance. Familiar forage and a gradual return to the normal feeding pattern may be helpful when safe and appropriate, while hydration and veterinary advice take precedence when a horse is ill or dehydrated. For Indian settings, the relevance may span working equids, breeding and racing yards, mounted services, sport horses and recreational animals; the same nutritional principles must be adapted to the work, body condition and available feed resources.

14.3 Practical considerations for Indian equids

Equids in India are managed under diverse conditions, including organized stables and racing yards, riding schools, breeding farms and working settings. Feed ingredients, forage continuity, water quality, heat exposure and access to veterinary care differ markedly between these groups. Advice should therefore avoid a single standard ration. Regionally available dry fodder and crop residues can be part of a plan when hygienic and suitable, but coarse or

low-quality material may not meet all requirements and may be difficult for animals with dental problems to utilize. Ration changes must also consider workload and the risk of contamination or mould during humid storage periods.

Extension materials can emphasize practical actions: weigh feed rather than estimate by volume, ensure forage availability appropriate to the horse's needs, provide clean water, inspect stored feed, transition diets slowly, monitor body condition and seek veterinary assessment for persistent clinical signs. Where laboratory testing is scarce, shared feed-analysis services and reliable forage sampling protocols could improve ration accuracy. Indian equine research would benefit from locally relevant forage databases, studies of working-equine energy requirements, heat and hydration management, and evaluation of traditional feeds with modern nutrient and safety analysis.

15. Evidence appraisal and future research directions

15.1 Matching the strength of evidence to the recommendation

Equine nutrition literature includes controlled feeding experiments, field observations, clinical case series, systematic reviews and practical experience. These sources answer different questions. A randomized trial may test a supplement under defined conditions but may not represent all breeds or workloads; an observational study can reveal associations but may be affected by management differences; a review can synthesize evidence but is constrained by the quality and heterogeneity of the included work. Strong recommendations should reflect the design, size and relevance of the available studies, not only whether one reported result was statistically significant.

The gut microbiome is a growing research area, but microbial associations should not be treated as a diagnostic signature without validation. Results vary with sampling location, feed, season, medications, laboratory pipeline and statistical method. Future work should connect microbial profiles with digestibility, metabolite production, clinical outcomes and animal performance. The review by Li et al. (2025) emphasizes the complexity and dynamism of equine microbiomes; it supports further study but does not imply that routine microbiome sequencing is currently needed for every horse.

15.2 Priority outcomes for applied studies

Future studies should standardize forage intake, dry-matter basis, digestibility endpoints, body-condition assessment, workload description and supplement reporting. Trials should consider baseline diet, environmental exposure and adherence, because a supplement cannot be interpreted independently of the ration in which it was tested. Long-term studies are needed to evaluate whether short-term changes in faecal microbiota or blood metabolites predict meaningful changes in colic, laminitis, performance, fertility or longevity. Independent replication and transparent reporting of negative findings can reduce overinterpretation and improve feeding decisions.

A practical research agenda for India includes characterization of regional grasses and conserved forages, reliable estimates of forage intake, nutrition of working equids, strategies for older horses with dental limitations, heat and hydration management, and field testing of low-cost monitoring tools. Research can also examine how feed quality, management and workload interact rather than testing each factor separately. The central objective is to improve welfare and clinical outcomes with diets that are nutritionally adequate, affordable and sustainable.

16. Forage preservation, feed handling and risk management

16.1 Hay, haylage and pasture are not interchangeable

Forage conservation changes moisture, microbial exposure, nutrient stability and dust characteristics. Hay requires drying to a safe storage moisture, while haylage is conserved at higher moisture under controlled anaerobic conditions and has distinct storage and spoilage risks. Pasture varies with plant species, maturity, weather and grazing pressure. The same nominal weight of hay and fresh pasture does not provide the same dry matter or nutrient supply. Feed plans should therefore identify the forage type and batch and should not substitute one form for another on an equal-weight basis without recalculation (Harris et al., 2017).

A forage reserve can support continuity, but storage management determines whether the reserve remains safe. Wet or poorly sealed haylage can spoil; hay may absorb moisture; and prolonged storage can alter acceptability or nutrient value. Mould, unusual odour, visible heating, dust and foreign material warrant attention. Forage analysis should be repeated when the source or harvest changes and particularly where the horse has a known metabolic or digestive concern. Feeding a poor-quality batch simply because it has already been purchased can create greater costs through reduced intake or health problems.

16.2 Forage alternatives and chewing limitations

Long-stem forage is suitable for many horses, but dental disease, choke risk, advanced age or specific medical conditions may require a different physical form. Chopped forage, soaked hay cubes, beet pulp or formulated complete feeds may be considered in selected cases, but the suitability depends on the horse and the product. Soaking can reduce dust and may leach soluble nutrients, while the prepared feed can spoil quickly in warm weather. Changes in texture can alter eating time and should be monitored, particularly when forage access is important for normal behaviour.

An alternative forage product should be assessed by its nutrient profile, particle length, moisture, energy density, palatability, storage behaviour and safety for the intended horse. A feed with a high fibre label may not replicate the chewing pattern or feeding time associated with long forage. Horses with dental problems may need repeated small meals and veterinary dental care. The aim is to maintain adequate fibre and nutrient supply while matching the physical form to chewing capacity and clinical needs, not to assume that one product can replace all forage for every horse.

16.3 Contaminants and label interpretation

Stored feed may be affected by mould, mycotoxins, soil, weeds, pesticide residues or contaminant plants. Risk varies by region, weather, crop and storage conditions. A visual inspection cannot rule out every hazard, and a laboratory test should be chosen according to the suspected problem. Feed contamination should be considered when multiple animals develop similar signs or performance falls after a new batch is introduced. Supplier traceability and batch records help identify whether the problem is isolated or widespread.

Supplement labels also require critical reading. Products may contain overlapping minerals, herbs, sugars or active ingredients, and feeding more than one product can unintentionally increase total intake. Claims based on in vitro results or changes in a laboratory marker are not equivalent to evidence of improved health or performance. A useful label review asks: which nutrient or function is being targeted, what dose is supplied at the recommended feeding rate, what evidence supports the claim, and whether the complete ration already meets that need. Veterinary advice is appropriate when a product is proposed for a diagnosed disorder or for a horse receiving medication.

17. Exercise physiology, recovery and practical feeding schedules

17.1 Feeding around work

Timing and size of meals should be adapted to workload, horse history and veterinary advice. Large concentrate meals close to strenuous exercise can be unsuitable for some horses, while access to forage and water needs careful planning around travel, competition and recovery. Feeding schedules should avoid unnecessary long periods without forage, yet individual management may need to account for clinical conditions, airway or gastrointestinal issues and event rules. The key is consistency and gradual adjustment rather than a single timing formula applied to all disciplines. For endurance or prolonged exercise, energy and fluid turnover differ from short, intense work. Sweating losses vary with temperature, humidity, fitness, workload and individual physiology. Electrolyte replacement should be based on likely losses and accompanied by free access to appropriate water; concentrates or supplements do not replace hydration. After exercise, appetite, drinking, recovery, manure and body-weight change can help identify whether a programme is adequate. Persistent depression, abnormal recovery, reduced intake or other clinical signs require veterinary evaluation rather than dietary experimentation.

17.2 Muscle condition, protein and energy density

Muscle development depends on training stimulus, energy adequacy, amino-acid supply, rest and health. Increasing crude protein beyond need is not a substitute for an appropriate training programme, and protein concentration alone does not establish amino-acid adequacy. Forage may provide most protein for maintenance horses, while growing horses, lactating mares and some performance horses may require closer attention to quality and quantity. The final ration should consider body condition and total calorie intake because protein supplementation can add energy or minerals as well as amino acids.

A horse losing topline or muscle mass may have inadequate intake, but pain, endocrine disease, dental problems, parasites or other illness should also be considered. Photographs, body condition, body weight estimates and workload records can help track change but cannot identify the cause independently. Feeding recommendations should not overinterpret visual appearance alone. A balanced review links diet analysis with clinical assessment and training history, and then evaluates whether changes in muscle condition, performance or recovery occur over a suitable time period.

17.3 Electrolytes, water and heat recovery

Sodium, chloride and potassium are central to fluid balance and neuromuscular function, but the appropriate intake depends on diet, sweating and workload. Ordinary salt provision may be adequate for some horses but insufficient for others under prolonged exercise and heavy sweating. The amount and form should be selected with a clear understanding of the horse's total ration, water intake and health status. Excessive or poorly timed supplement delivery may reduce palatability or create risk when water is restricted. Horses with renal, cardiac or other medical concerns need individualized veterinary guidance.

Hot weather management should combine shade, ventilation, workload adjustment, acclimation, water availability and monitoring of recovery. The effect of heat is not simply a nutrient problem; heat increases physiological strain and may change voluntary feed intake. If appetite decreases, ration density may need review, but a sudden change should also prompt checks for illness, water limitation and feed spoilage. The safest strategy links nutrition to the surrounding management system and includes clear criteria for pausing work and seeking veterinary help.

18. Equine nutrition case framework and knowledge translation

18.1 Three questions before changing the diet

First, define the outcome: weight loss, inadequate body condition, poor performance, recurrent digestive signs or a diagnosed metabolic disorder are different problems. Second, estimate current intake from forage, pasture, concentrates, treats and supplements, ideally on a dry-matter basis. Third, review clinical status, workload, dental function, environment and water access. This sequence reduces the likelihood of treating an underlying medical condition as a feed deficiency. It also makes the rationale for any supplement or diet change explicit and measurable.

After a change, select outcome measures appropriate to the original concern. For weight management, body weight trend and body condition are more informative than a single visual impression. For forage intake, repeated weights and refusals help test assumptions. For digestive health, appetite, manure and clinical signs should be recorded, while remembering that they cannot exclude serious disease. For performance, workload and recovery must be reasonably standardized. A useful feeding plan states when it will be reviewed and which result would justify continuing, modifying or stopping the intervention.

18.2 Evidence grading and conflicts of interest

Products intended to improve gut health, calmness, muscle development or recovery vary widely in the type and quality of evidence supporting them. A study with a small sample, short duration or a surrogate marker may generate a hypothesis but does not demonstrate a lasting clinical benefit. Industry-funded studies can contribute valuable data, but transparency about funding, comparator diets, exclusions and statistical methods is important. Reviews should avoid equating the number of published studies with certainty when the studies use different products, outcomes and horse populations. The strongest practical conclusions are those supported by replicated research, coherent physiology, relevant outcomes and reasonable transferability to the target horse. Evidence gaps should be stated explicitly. In particular, microbiome differences should be interpreted as associations unless causality has been tested, and supplement results should not be generalized across formulations with different strains, doses or active ingredients. A review article is most useful when it distinguishes established feeding principles from emerging hypotheses and encourages controlled field research where uncertainty is substantial.

18.3 Extension and research priorities in India

Extension resources should translate forage analysis and ration balance into practical steps for owners, stable managers and working-equin caretakers. Visual feed-quality checklists, measured ration records, gradual-transition guides, hydration plans and clear veterinary warning signs can be shared through veterinary colleges and equine services. Region-specific feed information would improve decisions when conserved fodder is scarce or composition varies. Research on locally available forage and by-products should include palatability, digestibility, safety and actual intake rather than only proximate composition.

Further priorities include body-weight estimation calibrated for diverse equid types, the nutritional needs of working equids under hot conditions, feed access and welfare in different housing systems, and validation of low-cost monitoring tools. Research should report work intensity, weather, feed ingredients, forage analysis and health status so findings can be replicated. The broader goal is to make evidence-based nutrition accessible without creating unnecessary dependence on high-cost supplements. A forage-centred plan, good water and feed hygiene, appropriate clinical care and records remain the core of good equine nutrition.

Table 7. Forage and ration assessment checklist

Assessment item	Why it matters	Practical method	Limit / interpretation
Forage batch identity	Composition changes with source and harvest	Label bale / batch and record storage	A single grab sample may be unrepresentative
Dry matter and intake	Converts feed to a comparable basis	Weigh offered feed and refusals	Pasture intake remains difficult to quantify
Fibre and energy	Influences digestive substrate and calorie supply	Use a reputable forage analysis	Do not infer all values from visual appearance
Protein and minerals	Supports maintenance, growth and reproduction	Calculate whole-ration supply	Avoid duplicating nutrients in multiple supplements
Feed hygiene	Dust, mould and contamination affect risk	Inspect, store dry, test where indicated	Clinical concerns require veterinary assessment

Interpretation: this table is a decision-support framework; confirm relevance to the species, production system and local evidence before application.

Table 8. Nutrition-related risks and appropriate first responses

Observed concern	Possible nutritional / management contributors	Appropriate first action	Important caution
Reduced appetite	Feed change, dental pain, water, heat, illness	Check feed, water and clinical signs	Persistent anorexia requires veterinary review
Weight gain / obesity	Energy intake exceeds actual need	Assess whole ration, turnout and exercise	Avoid severe unsupervised restriction
Weight loss	Low intake, poor teeth, disease, workload	Weigh feeds and investigate medical causes	Do not assume that higher-energy feed alone solves it
Colic signs	Many causes; feeding may be one risk factor	Seek prompt veterinary assistance	Do not delay care to try a ration change
Poor performance / sweating	Workload, hydration, illness or diet mismatch	Review work, water, recovery and clinical status	Electrolytes cannot replace water or treatment

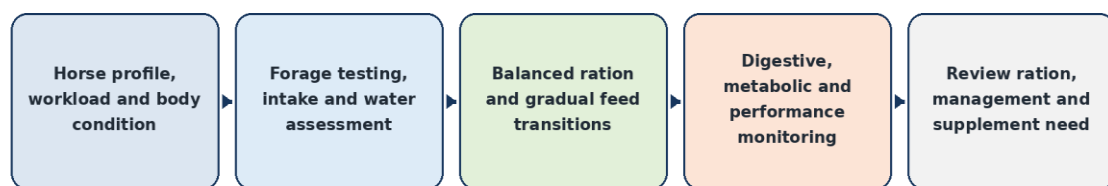
Interpretation: this table is a decision-support framework; confirm relevance to the species, production system and local evidence before application.

Table 9. Evidence hierarchy for equine supplements

Evidence / product feature	What it can tell the user	What it cannot establish alone
Replicated controlled trials in relevant horses	Potential effect under described conditions	Universal benefit across all horses and diets
Independent field studies	Practical performance beyond a single laboratory	Causation if management groups differ
Microbiome or biomarker change	Possible biological response	Clinical improvement without validated outcomes
Label claim or testimonial	May indicate intended use or user experience	Efficacy, safety or cost-effectiveness
Balanced ration and forage analysis	Whether an identified nutrient gap exists	Diagnosis of all clinical disease

Interpretation: this table is a decision-support framework; confirm relevance to the species, production system and local evidence before application.

Forage-centred equine nutrition framework



The sequence prioritizes forage and management before adding products or technology.

Interpretation: use species-specific data, verify the response and adapt the plan to local conditions.

Fig. 3. Forage-centred equine nutrition decision pathway. Conceptual figure prepared for this review; the pathway is intended to support, not replace, clinical assessment.

Table 10. Forage substitution considerations

Situation	Potential option	Nutritional / management check
Dental limitation	Soaked forage cubes or suitable complete feed	Particle form, chewing safety, nutrient completeness and spoilage
Dust sensitivity	Appropriate forage selection or soaking where suitable	Preserve required nutrients; hygienic preparation
Obesity / insulin risk	Measured forage and low-energy ration design	Analyse carbohydrate fractions; monitor condition and vet advice
Poor forage continuity	Conserved forage reserve and batch testing	Dry matter, hygiene, storage and gradual transitions
High workload	Forage plus appropriately balanced additional energy	Match to training, body condition, sweat loss and water

Interpretation: choose indicators before implementing the intervention and review outcomes alongside safety, welfare and economics.

Table 11. Practical follow-up after a ration change

Target	Baseline record	Review interval logic	Success indicator
Weight management	Weight estimate, body condition, complete ration	Regular repeated measures under consistent conditions	Trend toward target without loss of health or welfare
Digestive concern	Clinical diagnosis, feed history, manure and appetite	Follow veterinarian-defined monitoring plan	Clinical stability and appropriate intake
Performance / recovery	Workload, recovery, appetite, hydration	Compare similar work and weather where feasible	Recovery and work capacity with stable body condition
Forage intake	Offered feed, refusals, forage analysis	Repeat across representative days	Adequate, predictable intake and nutrient supply

Interpretation: choose indicators before implementing the intervention and review outcomes alongside safety, welfare and economics.

Conclusions

Equine nutrition is most robust when forage quality, adequate intake, nutrient balance, hydration and feeding behaviour are addressed before supplements are considered. The hindgut microbiome provides an important connection between diet and host function, but microbiome tests and functional products need careful interpretation. Precision assessment using feed records, body condition, workload and clinical monitoring can help individualize feeding without requiring full automation. For Indian equids, locally relevant forage data, practical education and affordable ration assessment remain important opportunities. A balanced plan should protect health and welfare while supporting the animal's actual workload and life stage.

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