

EVIDENCE-BASED EQUINE NUTRITION

Understanding Equine Nutrition

A practical, physiologically grounded guide to supplementation for horse owners and nutritionists

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Why This Guide?

As equine nutrition and metabolism consultants, we are frequently asked the same questions by horse owners who have encountered alarming claims online or in feeding guides: Is my horse getting too much iron? Does my mineral supplement contain the wrong form of selenium? Should I be supplementing vitamin E? Is the protein in my hay really adequate?

These are good questions, and they deserve honest, science-based answers. This guide was written to provide exactly that – not to promote any particular product, but to give horse owners and their nutritionists a clear, physiologically grounded framework for thinking about equine supplementation. We have drawn on peer-reviewed research, established nutritional physiology, and decades of clinical experience with horses across Europe and internationally.

Our starting point is always the same: the horse evolved as a grazing animal over roughly 50 million years. Its digestive system, its metabolic regulation, and its nutritional requirements are shaped by that evolutionary history of a forage-based diet. Understanding what the horse's body actually does with the nutrients it receives – and why – is the foundation of good feeding practice.

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Iron *– the most misunderstood mineral in equine nutrition*

Iron is one of the most frequently raised concerns in equine feeding discussions, and one of the most frequently misrepresented. The claim that horses are suffering from widespread chronic iron overload from their forage deserves careful examination.

What the numbers actually mean

The National Research Council (NRC) recommends a minimum daily iron intake of 400mg for a 500kg horse at maintenance. This figure is often cited alongside forage analysis results showing 300–500mg of iron per kg of dry matter, leading to the conclusion that a horse eating 10kg of hay per day is consuming up to ten times its requirement.

This comparison is misleading for two reasons. First, the NRC figure is a minimum requirement to prevent deficiency – not a safe upper limit. The NRC's tolerable upper limit for iron in horses is 500mg per kg of dry matter

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in the total diet, equivalent to approximately 5,000 - 7,500mg per day for a 500kg horse on 10 - 15kg of hay. A horse eating hay with 400mg of iron per kg is therefore well within the safe range, not dangerously above it.

Second – and this is rarely mentioned – a substantial proportion of the iron measured in hay analysis does not come from the grass plant at all. It comes from soil contamination: particles of soil that inevitably end up in stored forage. Soil is extremely rich in iron, but iron bound in soil particles cannot be converted into the absorbable Fe^{2+} form in the horse's stomach. It passes straight through the digestive tract and leaves with the manure. The Equi-Analytical database, with over 25,000 mixed grass hay samples analysed across 16 years, shows iron values ranging from essentially zero to over 12,800mg/kg, with a standard deviation so extreme that the average figure is statistically almost meaningless. That variability reflects soil contamination, not meaningful differences in how much iron the horse will absorb.

25,000+	~0–12,800	16
HAY SAMPLES ANALYSED	MG/KG IRON RANGE	YEARS OF DATA

Why the horse handles forage iron without difficulty

Horses have been grazing iron-rich vegetation for approximately 50 million years. Forage has always contained far more iron than horses need on a daily basis. Had the horse not evolved highly effective mechanisms to regulate iron absorption across that timeframe, the species would not have survived. Those mechanisms are well understood: iron from hay, grass and other inorganic mineral sources enters the gut and is absorbed through a tightly regulated transport system that responds directly to the horse's current iron status. When stores are adequate, absorption drops sharply. Excess inorganic iron remains in the gut and is excreted with the faeces.

But what about iron causing insulin dysregulation?

A peer-reviewed survey of 1,978 Thoroughbred racehorses (McLean, McGilchrist & Nielsen, 2022, Animals, 12:2510) found that horses consumed an average of 3,900mg of iron per day from forage and feed alone – nearly ten times the NRC minimum requirement – with supplements adding a further 500mg daily. Not one confirmed case of insulin resistance was recorded across the entire cohort. This does not mean iron is irrelevant to equine health, but it does make clear that dietary iron from forage is not an independent driver of metabolic disease.

Where the real risk lies: organic iron in supplements

The iron regulation described above applies to inorganic iron – the form found in hay, grass and properly formulated mineral supplements. It does not apply to organic iron chelates, in which iron is bound to amino acids. Chelated iron bypasses the gut's normal absorption controls entirely and enters the bloodstream via amino acid transporters, regardless of whether the horse needs more iron. Chronic supplementation with chelated iron can lead to liver accumulation and, over time, liver failure. This form is increasingly found in muscle, joint and recovery supplements as well as mineral feeds. It is the only form of dietary iron that poses a realistic toxicity risk – and it is the one that is almost never discussed.

WHAT TO CHECK ON YOUR LABELS

If you want to assess iron in your horse's diet, look at your supplement labels for the terms "iron chelate", "ferrous chelate" or "iron amino acid complex". Inorganic iron sources in a well-formulated mineral supplement are not a concern.

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Iron and hoof quality

One further claim circulates regularly: that high dietary iron causes poor hoof horn quality. The evidence does not support this. Hoof horn is approximately 93% protein on a dry matter basis, and its structural integrity depends on keratin, whose strength comes from sulphur-containing disulphide bonds between amino acid chains. The nutrients that actually determine hoof horn quality are zinc, sulphur-containing amino acids (particularly methionine and cysteine), copper and biotin. Removing iron from a mineral supplement will not improve your horse's hooves. Addressing zinc status, sulphur availability and gut health will.

Vitamin E *– when supplementation helps and when it doesn't*

Vitamin E is genuinely important for horses. It protects muscle cells from oxidative damage, supports immune function and plays a role in neurological health. It is also a nutrient that really does decline sharply in dried forage. The question is not whether vitamin E matters, but whether your horse is actually deficient – and the answer depends almost entirely on how much access to fresh grass your horse has.

What pasture actually provides

Fresh growing grass contains between 45 and 400 IU of vitamin E per kg of dry matter, with actively growing spring and summer grass consistently at the higher end of that range. A 500kg horse with good quality pasture access will typically consume enough natural vitamin E in 1.5 to 5 hours of grazing per day to meet its daily maintenance requirement of around 500–1,000 IU – depending on pasture quality and season.

Vitamin E is fat-soluble and stored in the liver and adipose tissue. A horse that grazes freely through spring and summer builds reserves that carry it through the winter. Research shows a clear seasonal pattern in plasma vitamin E concentrations: values peak in summer in horses on pasture and decline over winter, but in horses with adequate summer grazing, levels typically remain adequate throughout a normal winter on good quality hay. Vitamin E deficiency is primarily a concern for horses that have had little or no access to fresh grass for extended periods.

Natural versus synthetic vitamin E: why form matters

If supplementation is genuinely indicated, the form of vitamin E used makes a significant practical difference. Natural vitamin E (d-alpha-tocopherol, also written as RRR-alpha-tocopherol) is the form found in plants and is the stereoisomer that horse tissues absorb and utilise most efficiently. Synthetic vitamin E (dl-alpha-tocopherol) is a mixture of eight stereoisomers, of which only one – at 12.5% of the total – is the biologically preferred RRR form. Doubling the dose of synthetic vitamin E cannot compensate for this structural disadvantage.

+77%	+33%	8
SERUM RISE, NATURAL FORM	SERUM RISE, SYNTHETIC FORM	ISOMERS IN SYNTHETIC E

A peer-reviewed study in exercising horses (Fagan et al., 2020, Journal of Equine Veterinary Science, 91:103103) found that natural vitamin E at 4,000 IU per day produced a 77% increase in serum alpha-tocopherol, compared to just 33% for the same dose of synthetic vitamin E. The natural form also resulted in lower markers of oxidative damage and lower inflammatory cytokine activity. Synthetic vitamin E dominates commercial feeds and supplements because it is cheaper and has a longer shelf life – not because it works better.

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A note on high-dose supplementation and training adaptation

There is a further consideration for sport horse owners that is rarely discussed in equine nutrition. Free radicals produced during exercise are not purely damaging – they also act as signalling molecules that trigger the cellular adaptations to training, including mitochondrial biogenesis and the upregulation of the body's own antioxidant defences. When exogenous antioxidants are provided in high doses, they can blunt these redox-sensitive signalling pathways, interfering with the very adaptations that make training effective.

A double-blind, randomised, controlled trial in humans (Paulsen et al., 2014, Journal of Physiology, 592:1887–1901) found that combined vitamin C and E supplementation hampered endurance training-induced increases in mitochondrial proteins, despite subjects training identically to the placebo group. A 2020 review (Braakhuis & Hopkins, International Journal of Environmental Research and Public Health, 17:8452) concluded there is convincing evidence that vitamins C and E blunt skeletal muscle adaptations to endurance training. The mechanism is not species-specific. Routinely supplementing vitamin E in horses with adequate status from pasture access may therefore work against the training process rather than supporting it.

Who genuinely needs supplementation

Horses confined to grass-free paddocks or tracks due to laminitis or metabolic conditions; horses in intensive training with no pasture access; horses on heavily overgrazed or predominantly bare pastures; and horses showing clinical signs of deficiency such as muscle weakness, poor recovery or neurological symptoms including equine motor neuron disease (EMND). For a horse with reasonable summer turnout and decent winter hay, routine high-dose vitamin E supplementation adds cost without adding meaningful benefit.

Protein *– quality over quantity*

The claim that hay is always too low in protein to meet horses' needs is frequently encountered, but it is not well supported across the range of horses and management systems it is applied to.

When hay protein is actually sufficient

A 500kg horse in light to moderate work needs roughly 650–750g of digestible crude protein per day. A horse eating 10kg of hay at 8% crude protein is already consuming 800g before accounting for any contribution from the hindgut microbiome. Good quality mixed grass hay in the UK and Europe typically contains between 6 and 9% crude protein (ranging from 4 to 14%) – sufficient to meet the maintenance requirements of most adult leisure horses without any supplementation.

Protein requirements do increase meaningfully in specific circumstances: lactating mares in the first months of nursing, foals and young horses in active growth, horses in very heavy training building significant muscle mass, and older horses with progressive muscle atrophy. For most leisure and lightly worked horses, a solid hay-based diet is not protein-deficient.

The amino acid question is the right one to ask

Where horse diets can genuinely fall short is not in total protein but in the essential amino acids lysine, methionine, and threonine, which are the primary limiting factor in equine protein utilisation. Regardless of how much crude protein is available, if one of the three is insufficient, the rest cannot be used efficiently.

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The practical solution is targeted supplementation of essential amino acids, or the inclusion of high-quality fibre-based protein sources such as sainfoin (esparsette) or lucerne, which provide excellent amino acid profiles without the digestive complications associated with grain or proteins from sources such as soy, peas or whey. These plant-based legume options are also far gentler on the hindgut.

What a Ration Balancer is – and when it is appropriate

It is worth clarifying the difference between a mineral feed and a ration balancer, as the two serve different purposes and are sometimes confused.

Mineral supplement / mineral feed

Designed to provide minerals and trace elements – it fills the gaps in what forage provides, without adding significant protein, calories or other macronutrients.

MINERALS ONLY

Ration balancer

Contains minerals and trace elements alongside a meaningful level of protein, specifically to compensate for shortfalls in the forage's amino acid profile.

MINERALS + PROTEIN

Ration balancers are appropriate when forage analysis confirms that protein levels are genuinely below requirements – for example, in very late-cut hay from marginal land, in drought years, or for horses with elevated protein needs such as those described above. They are not necessary for a horse on adequate hay whose primary need is mineral balance.

A NOTE ON OVERFEEDING PROTEIN

Excess protein is not stored as muscle. It is broken down in the liver, with the nitrogen excreted as urea via the kidneys. Chronically high protein diets load the liver and kidneys, elevate blood urea, and in horses not doing the work to justify the intake, the carbon skeleton of the amino acids is converted to glucose and / or fat – contributing to weight gain, fat deposition or lymph retention depending on the horse's metabolic type. Many horses that appear "rounded" are not well-muscled: they are protein-overloaded.

Calcium, Phosphorus and Magnesium

The calcium to phosphorus ratio

Calcium and phosphorus must always be considered together. In the horse's body, approximately 99% of calcium and 80% of phosphorus are found in bone, where they are held in a ratio of roughly 2:1 (calcium to phosphorus). The diet should ideally reflect a ratio in the range of 2:1 to 6:1. Ratios below 2:1, where phosphorus exceeds or approaches calcium, are problematic if sustained over time, as the body draws calcium from bone to restore balance. The horse can tolerate ratios up to approximately 10:1 for short periods, but this is not a target to aim for.

Grass hay and pasture globally – whether in Europe, North America or Australasia – is naturally calcium-rich and relatively phosphorus-poor. This means forage-based diets typically provide a favourable calcium to phosphorus ratio without intervention. The ratio becomes a practical concern primarily when significant amounts of cereal grains are fed – oats, barley and particularly maize are heavily phosphorus-dominant – or when feeds high in phytates (such as wheat bran) or oxalates (such as alfalfa) are given regularly. Phytates and oxalates bind calcium

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in the gut and render it unavailable, which can provoke a functional calcium deficiency even when total calcium in the ration appears adequate.

The vitamin D system – involving parathyroid hormone and calcitonin – actively regulates the calcium to phosphorus balance in the body. A horse with adequate vitamin D status, sufficient sun exposure and good quality forage has a considerable degree of self-correction available. This is why obsessive precision over the exact dietary ratio, while theoretically appealing, is less critical in a forage-based system than it would be in a highly processed diet.

Magnesium: an underappreciated partner mineral

Magnesium is essential for muscle contraction and relaxation, nerve conduction, energy metabolism in the Krebs cycle, and as a cofactor in a large number of enzyme reactions. It is also closely involved in calcium metabolism: adequate magnesium is necessary to prevent pathological calcium deposition in soft tissues such as arterial walls and kidneys, which can occur when calcium and phosphorus are oversupplemented relative to magnesium.

Grass and hay globally – including across Europe, North America and Australasia – typically contains magnesium in amounts that meet the maintenance requirements of most horses on a forage-based diet. Primary magnesium deficiency from inadequate intake is uncommon in horses with access to good quality forage. The more clinically relevant issue is competitive inhibition: high calcium levels in the diet can reduce magnesium absorption, which means the absolute magnesium content of the forage is not always the whole picture. A balanced mineral supplement that provides magnesium in appropriate proportion to calcium addresses this effectively, together with a forage-based diet.

Magnesium requirements increase during heavy sweating – sport horses in summer training may need additional electrolyte support that includes magnesium. Horses with metabolic conditions and those showing signs of muscle tension, nervousness or heightened reactivity may also benefit from assessed magnesium support, though it is worth noting that these signs have multiple possible causes and should not be attributed to magnesium deficiency without proper evaluation.

> A note on the relationship between calcium and magnesium: very high calcium intake can reduce magnesium absorption in the gut. This means that excessive calcium supplementation – for example, through liberal use of limestone flour on top of a calcium-rich hay – can induce a functional magnesium deficiency even when magnesium intake appears adequate. Balance across minerals matters more than the absolute quantity of any single mineral.

How to Read a Mineral Feed Label

Crude ash: the key quality indicator

When evaluating a mineral supplement, one of the most informative numbers on the label is the crude ash content. Crude ash represents the total mineral content of the product – it is what remains when the organic material is burned away. A high crude ash value means the product contains a large proportion of actual minerals relative to its total weight.

A mineral supplement with a crude ash content of only 15% contains 85% of something else – carriers, fillers, flavourings, starch or other bulking agents. That means you are paying for a product whose primary content is

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not minerals, but cheap fillers. A high-quality mineral feed will typically show crude ash values of at least 40%. When crude ash exceeds 40%, it does not need to be on the label. When comparing products, always check this figure first.

A good mineral supplement works like a buffet

The logic behind a well-formulated mineral supplement containing the full spectrum of minerals and trace elements – rather than targeting specific ones – deserves explanation, because it is often misunderstood.

No two batches of hay are identical in their mineral composition. The mineral content of forage varies with soil type, growing conditions, rainfall, fertilisation history, grass species and cutting time. A hay that is low in zinc in one year may be adequate the following year, even from the same field. The same field managed differently can produce hay with quite different copper and selenium levels. And even in hay from the same field we find variations in mineral contents from one bale to the next.

A balanced mineral supplement that provides all the major minerals and trace elements in physiologically appropriate amounts and ratios works as a nutritional safety net across this variability. The horse's gut regulates the uptake of inorganic minerals based on what it actually needs. Where the forage already provides adequate levels of a particular mineral, the gut absorbs less of that mineral from the supplement and it passes through in the faeces. Where the forage is deficient, more is absorbed. This means a comprehensive, balanced mineral feed effectively corrects deficiencies and avoids oversupply – without requiring every hay batch to be individually analysed.

> This self-regulating system only works when minerals are provided in inorganic form. Organic chelates bypass the gut's absorption controls, as discussed in the iron chapter. A supplement built on inorganic mineral sources, with a high crude ash content, allows the horse's own physiology to make the fine adjustments. That is not a design compromise – it is the most physiologically intelligent way to support mineral balance in a forage-based diet.

Organic Selenium *– the risk no one talks about*

Selenium is essential in small amounts and toxic in slightly larger ones. The therapeutic window is narrower for horses than for almost any other domesticated animal, which makes the widespread use of organic selenium in equine supplements a subject that deserves serious attention.

Inorganic versus organic selenium: a fundamental difference

The selenium found in grass and hay is primarily inorganic – selenite or selenate – present in trace amounts. The horse's gut absorbs it through specific selenium transport mechanisms that are regulated in response to the body's current selenium status. When selenium stores are adequate, absorption decreases. This regulatory system evolved over millions of years of exposure to forage-level selenium.

Organic selenium – in the form of selenomethionine or selenocysteine, found in selenium yeast products – is absorbed via amino acid transporters. These transporters do not recognise it as selenium. They process it as a sulphur-containing amino acid, absorbing it regardless of the horse's selenium status. There is no regulatory brake. The horse cannot distinguish between methionine and selenomethionine at the point of absorption, which means organic selenium enters the body in essentially uncontrolled amounts relative to need.

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What happens to organic selenium once inside the horse

Once absorbed, organic selenium is incorporated into body proteins – in place of sulphur-containing amino acids like methionine and cysteine. This is where the problem begins. Selenium cannot form the disulphide bonds that give structural proteins their mechanical strength. Keratin, the protein that forms hoof horn, depends on disulphide bonds for its integrity. When selenocysteine is incorporated into keratin in place of cysteine, the resulting structure is mechanically weaker than normal.

In practice, this manifests as horizontal cracks in the hoof capsule, poor white line integrity, recurring hoof abscesses that are frequently misdiagnosed, progressive deterioration in hoof horn quality, predisposition for laminitis, and changes in hair and coat quality. These signs often appear 12 to 18 months after the introduction of organic selenium. By this point, the connection to selenium supplementation is rarely made.

THE DELAYED RELEASE AND ITS CONSEQUENCES

The horse's protein turnover cycle – the continuous process of breaking down old proteins and rebuilding new ones – takes approximately one year to cycle through the entire proteome. This means that organic selenium incorporated into structural proteins is released gradually back into circulation over that period, long after supplementation may have stopped. Blood selenium levels can rise sharply 12 to 36 months after organic selenium feeding began or ended, as accumulated selenomethionine and selenocysteine is released during protein breakdown.

When released selenium enters circulation, it can displace chromium from the insulin signalling cascade in muscle cells, blocking the link between the insulin receptor and the glucose transporter. This produces a pattern of insulin dysregulation that resembles EMS or early Cushing's syndrome – and which is frequently treated as such, without the underlying cause being identified. The laminitis risk that follows from this insulin dysregulation is real and has been documented clinically. A horse that develops apparent EMS or recurring laminitis without clear dietary sugar or starch loading as a trigger should prompt a careful review of selenium supplementation history, particularly organic selenium.

The practical recommendation

Geologically, selenium deficiency in soils is a localised phenomenon tied to specific rock formations – mountainous regions with young igneous soils and high rainfall leaching. The agricultural lowlands and mixed farming regions where the vast majority of leisure horses are kept worldwide fall within the normal geochemical range for soil selenium. A horse on a well-managed forage-based diet in these regions will typically receive selenium in amounts that approach its physiological requirement without supplementation.

A mineral feed containing a modest, appropriate level of (inorganic) sodium selenite covers any shortfall safely. Products claiming superior bioavailability for organic selenium forms are not offering an advantage for horses – they are offering a faster route to deteriorating health.

If a horse has been receiving organic selenium for an extended period, it is not possible to rapidly clear the accumulated stores. The protein turnover cycle must run its course. Supporting the horse with a correctly balanced inorganic mineral feed, removing all organic selenium sources, and monitoring for the signs described above is the appropriate management strategy.

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A Framework for Advising Clients

The questions horse owners most frequently bring to their nutritionists can be summarised as a concern about whether their current feeding programme is leaving their horse deficient in something important. That concern is legitimate and worth taking seriously. The answer, in most cases, is more straightforward than the supplement industry would have you believe – and it is worth remembering that the fear of getting it wrong is precisely what supplement marketing is designed to exploit.

A horse with the following foundation is nutritionally well supported in the vast majority of cases:

Good quality hay, ad libitum

With a crude protein content of 6–9% and a sugar content appropriate to the horse's metabolic status (under 10%, ideally under 6% for good doers). For horses that cannot access pasture, hay analysis is the single most valuable investment in nutritional clarity.

Access to fresh pasture

For at least part of the grazing season, providing natural vitamin E, beta-carotene and a broad spectrum of plant-based micronutrients that hay cannot replicate.

A well-formulated mineral feed

With a high crude ash content, containing the full spectrum of minerals and trace elements in inorganic form and physiologically balanced ratios. This allows the horse's own gut physiology to correct for whatever the current hay batch happens to be lacking, without requiring individual hay analysis for every bale.

A salt lick

Providing sodium chloride freely, separate from the mineral supplement.

Beyond this foundation, additional supplementation should be driven by specific, identified need – confirmed by forage analysis, clinical observation or blood testing where relevant – rather than by precautionary logic or marketing claims. The most common drivers of genuine nutritional problems in horses are not iron overload from forage, but poor hindgut microbiome health, chronic low-grade gut wall inflammation, kryptopyrroluria (KPU) in horses with elevated mineral turnover, and the consequences of long-term organic selenium accumulation. These are the areas where targeted therapeutic support makes a meaningful difference.

> When in doubt, the most important question to ask is not "what might my horse be missing?" but "does my horse's gut have the health to actually absorb and use what is already in the diet?" The best mineral supplement in the world cannot compensate for a compromised hindgut. Good forage quality, appropriate management, and a healthy microbiome are the foundation on which everything else depends.

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