

THE EVOLVING SCIENCE OF MARINE BIOACTIVES IN EQUINE NUTRITION

Re-thinking Equine Nutrition Through
the Lens of Gut Health



EXECUTIVE SUMMARY

For decades, equine seaweed supplementation has been synonymous with the use of brown seaweeds and most commonly *Ascophyllum nodosum* (*Ascophyllum*), often shortened to Asco and sometimes mislabelled as kelp. While *Ascophyllum* is a valuable brown seaweed rich in fucoidan, laminarin, alginate, and minerals, modern marine science shows it represents **only one branch** of a broad family of macroalgae with distinct and complementary biological properties.

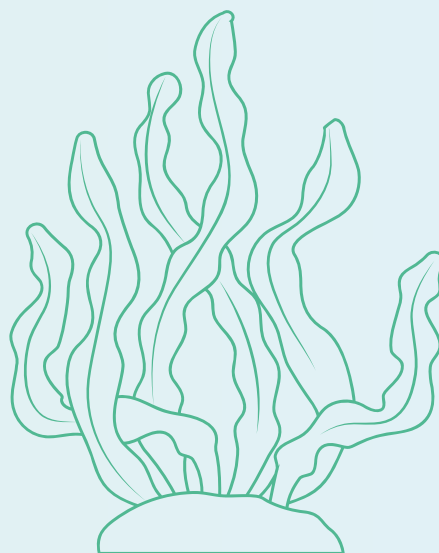
In contrast, **green seaweeds** (e.g., *Caulerpa*, *Codium*, *Ulva*) and **red seaweeds** (e.g., *Chondrus*, *Gracilaria*, *Palmaria*, *Porphyra*) contain **completely different classes of polysaccharides**, antioxidants, and functional bioactives that act on *different physiological pathways*.

A growing body of evidence demonstrates that **multi-seaweed formulations** — those which incorporate brown, green, and red macroalgae in rational ratios — offer **far superior functional benefits** for horses, especially in:

-  Hindgut fermentation
-  Microbiome stability
-  Behaviour and gut-brain axis
-  Hoof and coat integrity
-  Immune modulation
-  Performance and recovery
-  Digestive consistency

This whitepaper presents:

1. A scientific tour of **major seaweed groups**
2. Clarification of misconceptions around *Ascophyllum*-only products
3. Expected equine effects based on known marine polysaccharide biology
4. Alignment between **real field results** and **mechanistic predictions**
5. A full appendix of independent, peer-reviewed research supporting each claim



This is the **new scientific narrative** around marine bioactives in horses.

THE MARINE BIOACTIVE LANDSCAPE: BROWN, GREEN, AND RED SEAWEEDS

The three major macroalgal groups differ radically in composition.

BROWN SEAWEEDS

Brown macroalgae are characterised by a distinctive suite of sulphated and non-sulphated polysaccharides and polyphenolic compounds, most notably fucoidans, laminarins, alginates, and phlorotannins, alongside a naturally high mineral and trace element content.

Key bioactives:

- 🌿 Fucoidans (sulphated fucose-rich polysaccharides)
- 🌿 Laminarin (β -glucan storage polysaccharide)
- 🌿 Alginates (gel-forming structural polysaccharides)
- 🌿 Phlorotannins (marine polyphenols)
- 🌿 Marine-derived minerals



Known biological actions:

Independent studies demonstrate that brown seaweed polysaccharides and polyphenols:

- 🛡️ Modulate innate immune signalling, including reductions in pro-inflammatory cytokine activity and altered immune cell responses (*Ale et al., 2011; Fitton et al., 2015*)
- 🧬 Support epithelial and barrier integrity, through effects on cell differentiation and structural maintenance (*Yao et al., 2023*)
- 🦠 Exert antimicrobial and anti-adhesive effects against selected microbial species, contributing to microbial balance rather than broad-spectrum suppression (*Fitton et al., 2015*)
- 🐎 Influence keratinocyte differentiation and tissue structure, supporting skin and keratinised tissue integrity at a cellular level (*Chen et al., 2019; Song et al., 2014*)
- 🔄 Provide antioxidant activity, largely via phlorotannins and associated polyphenols,

RELEVANCE TO HORSES



In **equine** systems, these mechanisms are most relevant to immune tone, epithelial resilience, skin and hoof tissue biology, and oxidative balance, rather than direct effects on hindgut fermentation.

GREEN SEaweEDS

Green macroalgae are distinguished by their content of rhamnose-rich sulphated polysaccharides (ulvans), alongside chlorophyll derivatives and highly fermentable soluble fibre fractions.

Key bioactives:

- 🌿 Ulvans (rhamnose-rich sulphated polysaccharides)
- 🌿 Fermentable soluble fibres
- 🌿 Chlorophyll-associated compounds



Known biological actions:

Studies consistently show that green seaweed polysaccharides:

- 🌀 Resist digestion in the upper gastrointestinal tract, allowing delivery to the hindgut for microbial fermentation (*O'Sullivan et al., 2010; Charoensiddhi et al., 2022*)
- 🍷 Are selectively fermented by gut microbiota, stimulating fibrolytic and butyrate-producing bacterial taxa, including members of the *Ruminococcaceae* and *Lachnospiraceae* families (*Seong et al., 2019; Han et al., 2019*)
- 🔄 Increase total short-chain fatty acid production, including butyrate, a key energy source for intestinal epithelial cells (*Cherry et al., 2019; Charoensiddhi et al., 2022*)
- 🛡️ Modulate inflammatory signalling, including suppression of LPS-driven immune activation (*Leiro et al., 2007*)
- 🔄 Contribute antioxidant activity, through associated pigments and polysaccharide-linked effects (*Xie et al., 2023*)

RELEVANCE TO HORSES



Given the horse's reliance on hindgut fermentation, green seaweeds are particularly relevant as prebiotic substrates that support fibre-degrading microbial populations, stable SCFA production, and fermentation-driven gut comfort.

RED SEAWEEDS

Red macroalgae contain structurally distinct sulphated galactans, including agarans, carrageenans, and porphyran, alongside unique polyphenolic compounds.

Key bioactives:

- 🔥 Sulphated galactans (agarans, carrageenans, porphyran)
- 🔥 Gel-forming soluble fibres
- 🔥 Red seaweed polyphenols



Known biological actions:

Evidence indicates that red seaweed polysaccharides:

- 🌀 Form hydration-stable gels within the gastrointestinal tract, influencing digesta viscosity and water retention (*Xie et al., 2023*)
- 🔄 Support short-chain fatty acid production, through microbial fermentation of sulphated galactans (*Zhu et al., 2021*)
- 🔄 Exert potent antioxidant effects, reducing oxidative biomarkers and contributing to redox balance (*Zhang et al., 2015*)
- 🧬 Modulate inflammatory pathways, supporting controlled immune signalling and mucosal comfort (*Ale et al., 2011; Zhang et al., 2015*)
- 🧬 Contribute to intestinal barrier support, through combined physical and biochemical mechanisms (*Yao et al., 2023*)

RELEVANCE TO HORSES



In **horses**, these properties are most relevant to manure consistency, hydration balance, mucosal comfort, oxidative stress management, and resilience during dietary or environmental stress.

CHALLENGING MISCONCEPTIONS ROOTED IN THE HISTORY OF BROWN SEAWEED USE

Most veterinarians and equine nutritionists will likely have only encountered **pure *Ascophyllum nodosum*** supplements, which:

- ✓ Can have variable and often **high levels of iodine**, limit safe feeding rates and create uncertainty around use (*Teas, J. et al. 2004*);
- ✓ Provide **immune modulation** but weak microbiome restructuring;
- ✓ Offer **antioxidants**, but not the breadth seen in reds and greens;
- ✓ Lack meaningful **prebiotic fermentability**;
- ✓ Deliver **minimal stool-stabilising effects**.

Therefore, many clinicians have formed the impression:

"Seaweed has limited equine value."

In reality:

- 🌿 ***Ascophyllum* alone offers a narrower range of functional benefits relative to a multi-seaweed approach.**
- 🌿 **The rest of the seaweed world has up until now simply never really been part of the conversation.**
- 🌿 Brown, green, and red seaweeds each solve different biological problems; together they form a **complete marine bioactive system** and one that can be particularly valuable for horses.



GUT MICROBIOME & HINDGUT FERMENTATION IN THE HORSE

Horses are obligate hindgut fermenters and rely on a dense, metabolically active microbial ecosystem within the caecum and colon to extract energy from dietary fibre. Through microbial fermentation, complex carbohydrates that escape enzymatic digestion in the foregut are converted into short-chain fatty acids (SCFAs), principally acetate, propionate, and butyrate. These metabolites provide a substantial proportion of the horse's daily energy requirements and play a central role in maintaining epithelial integrity, immune regulation, and gastrointestinal stability (*De Fombelle et al., 2003; Julliand & Grimm, 2016*).

Foundational physiological studies have demonstrated that the hindgut harbours markedly higher populations of anaerobic and cellulolytic microorganisms than the foregut, alongside substantially greater concentrations of volatile fatty acids and distinct pH profiles. These studies confirmed the hindgut as the primary site of microbial fermentation in horses and showed that dietary composition strongly influences fermentation patterns, with forage-based diets supporting fibrolytic activity and more stable fermentation end-products (*De Fombelle et al., 2003*).



Advances in molecular sequencing have since enabled detailed characterisation of the equine hindgut microbiome. Early next-generation sequencing studies revealed that healthy horses typically exhibit a diverse microbial community dominated by members of the *Firmicutes* phylum, particularly fibrolytic and saccharolytic families such as *Ruminococcaceae* and *Lachnospiraceae* (*Dougal et al., 2012; Steelman et al., 2012*). These taxa are central to fibre degradation and SCFA production, underpinning efficient energy extraction and hindgut stability. Subsequent studies have confirmed substantial inter-individual variability but consistently highlight microbial diversity and fibrolytic dominance as hallmarks of a resilient hindgut ecosystem (*Julliand & Grimm, 2016; Curadi et al., 2025*).

The equine hindgut microbiome is highly responsive to dietary substrate availability. Diets that increase the flow of rapidly fermentable carbohydrates to the hindgut have been shown to alter microbial community structure, reduce microbial evenness, and promote a shift toward amylolytic and lactate-producing bacteria. These changes are frequently accompanied by altered fermentation profiles, including increased lactate concentrations and greater variability in hindgut conditions, which can compromise epithelial function and digestive comfort (Steelman *et al.*, 2012; Destrez *et al.*, 2019).

Beyond digestion alone, emerging evidence demonstrates that diet-induced modulation of the hindgut microbiome is functionally linked to behavioural responses in horses. Controlled studies have shown associations between microbial community shifts, fermentation by-products, and behavioural indicators of stress or reactivity during challenge, supporting the relevance of the microbiota–gut–brain axis in equine physiology (Destrez *et al.*, 2019). Integrative reviews further suggest that disturbances in microbial balance and fermentation may contribute to gastrointestinal discomfort and colic risk, although causality is complex and multifactorial (Lara *et al.*, 2022).



More recent comparative studies have strengthened the clinical relevance of these findings. Horses with a history of gas or impaction colic have been shown to exhibit distinct hindgut microbial and fermentative profiles compared with unaffected animals, including reduced microbial evenness, depletion of fibre-degrading taxa, increased abundance of lactate-producing bacteria, and elevated fecal lactate concentrations. Importantly, these differences have been observed under identical dietary and management conditions, suggesting that intrinsic differences in hindgut microbial ecology and fermentation balance contribute to susceptibility rather than simply reflecting current feeding practices (Yano *et al.*, 2025).



Collectively, this body of evidence demonstrates that equine gut health is not determined solely by nutrient intake, but by the maintenance of a stable, diverse, and fibrolytic-dominated hindgut microbial ecosystem capable of producing SCFAs in a controlled and sustained manner. Nutritional strategies that support microbial diversity, balanced fermentation, and epithelial energy supply are therefore foundational to digestive comfort, behavioural stability, and performance resilience in horses.

PREDICTED EFFECTS ON HINDGUT FERMENTATION AND DIGESTIVE STABILITY

Marine polysaccharides derived from brown, green, and red seaweeds share a critical functional property: resistance to enzymatic digestion in the upper gastrointestinal tract, allowing them to reach the hindgut intact where they become substrates for microbial fermentation (*O'Sullivan et al., 2010; Charoensiddhi et al., 2022*).

In vitro and *in vivo* fermentation studies demonstrate that seaweed-derived polysaccharides are selectively fermented by gut microbiota, stimulating fibrolytic and saccharolytic taxa while increasing total short-chain fatty acid (SCFA) production, particularly acetate and butyrate (*Cherry et al., 2019; Seong et al., 2019; Han et al., 2019; Zhu et al., 2021*). These effects have been observed across monogastric, herbivorous, and mixed-feeding systems, supporting conservation of the underlying mechanism.

In horses, where energy extraction and gut stability depend on sustained hindgut fermentation, these mechanisms predict:

- More stable fermentation profiles, driven by increased availability of fermentable substrates for fibrolytic bacteria
- Enhanced SCFA production, supporting epithelial energy supply and luminal pH stability
- Improved digestive consistency, through reduced reliance on rapidly fermentable starch entering the hindgut

These predicted effects align closely with equine studies demonstrating that microbial diversity, fibrolytic dominance, and controlled fermentation are hallmarks of a resilient hindgut ecosystem (De Fombelle et al., 2003; Dougal et al., 2012; Julliand & Grimm, 2016).



IMMUNOLOGICAL TONE, INFLAMMATION, AND GUT BARRIER FUNCTION

Beyond fermentation, marine polysaccharides exert direct immunomodulatory effects at the gut and systemic level. Fucoidans from brown seaweeds have been shown to modulate innate immune signalling and reduce pro-inflammatory cytokine activity (Ale et al., 2011; Fitton et al., 2015). Ulvan-type polysaccharides from green seaweeds suppress LPS-induced inflammatory responses, indicating a capacity to dampen excessive immune activation in the gut environment (Leiro et al., 2007).

- 🔥 Red seaweed sulphated galactans further contribute antioxidant and anti-inflammatory effects, reducing oxidative biomarkers and supporting mucosal comfort (Zhang et al., 2015). Importantly, several studies indicate that seaweed polysaccharides support intestinal barrier integrity, reducing permeability and reinforcing epithelial structure (Yao et al., 2023).

In horses, where low-grade inflammation and barrier disruption can occur in response to dietary change, exercise stress, or hindgut dysbiosis, these mechanisms predict:

- Reduced background inflammatory tone
- Improved gut barrier resilience, limiting immune activation driven by luminal antigens
- Greater tolerance to dietary and environmental stressors

These effects are consistent with equine literature linking gut integrity and immune balance to digestive comfort, recovery, and overall resilience (Costa et al., 2012; Stewart et al., 2017).

HOOF, SKIN, AND KERATINISED TISSUE SUPPORT

Keratinised tissues such as hoof horn and skin are sensitive to systemic inflammation, oxidative stress, and nutrient utilisation efficiency. Marine bioactives influence these systems through indirect but biologically coherent pathways.

- 🔥 Fucoidans from brown seaweeds have been shown to stimulate keratinocyte differentiation and support epidermal barrier formation in vitro (Chen et al., 2019; Song et al., 2014). Concurrently, antioxidant compounds present in both brown and red seaweeds reduce oxidative load, which is known to impair tissue growth and structural integrity (Ale et al., 2011; Zhang et al., 2015).





In horses, where hoof horn quality and skin condition reflect long-term metabolic and inflammatory status, these mechanisms predict:

- Improved keratinised tissue integrity, supported by reduced oxidative and inflammatory pressure
- More consistent hoof horn growth and quality, particularly under training or environmental stress
- Improved coat and skin condition, as downstream expressions of improved gut-mediated nutrient utilisation

These predictions align with foundational equine research linking systemic health, inflammation, and nutrition to hoof and skin biology (Pollitt, 2010; Miller et al., 2013).

BEHAVIOURAL STABILITY AND THE MICROBIOTA–GUT–BRAIN AXIS

Short-chain fatty acids produced during hindgut fermentation, particularly butyrate, act not only as energy substrates but also as signalling molecules within the microbiota–gut–brain axis. SCFAs influence serotonin synthesis, vagal nerve signalling, and neuroinflammatory pathways (Cryan & Dinan, 2012; Dalile et al., 2019).

Dietary studies in horses have demonstrated that shifts in hindgut microbiota composition and fermentation profiles are associated with altered behavioural reactivity and stress responses, particularly under high-starch or fermentative challenge conditions (Bulmer et al., 2015; Bulmer et al., 2019; Destrez et al., 2019).

By supporting fibrolytic fermentation and reducing inflammatory and discomfort signals arising from the hindgut, marine polysaccharide-driven modulation predicts:

- Calmer behavioural responses
- Improved focus and trainability
- Reduced stress-related reactivity associated with digestive discomfort

These outcomes are not behavioural “sedation” effects, but downstream expressions of improved gut comfort and metabolic signalling.

PERFORMANCE, RECOVERY, AND METABOLIC RESILIENCE

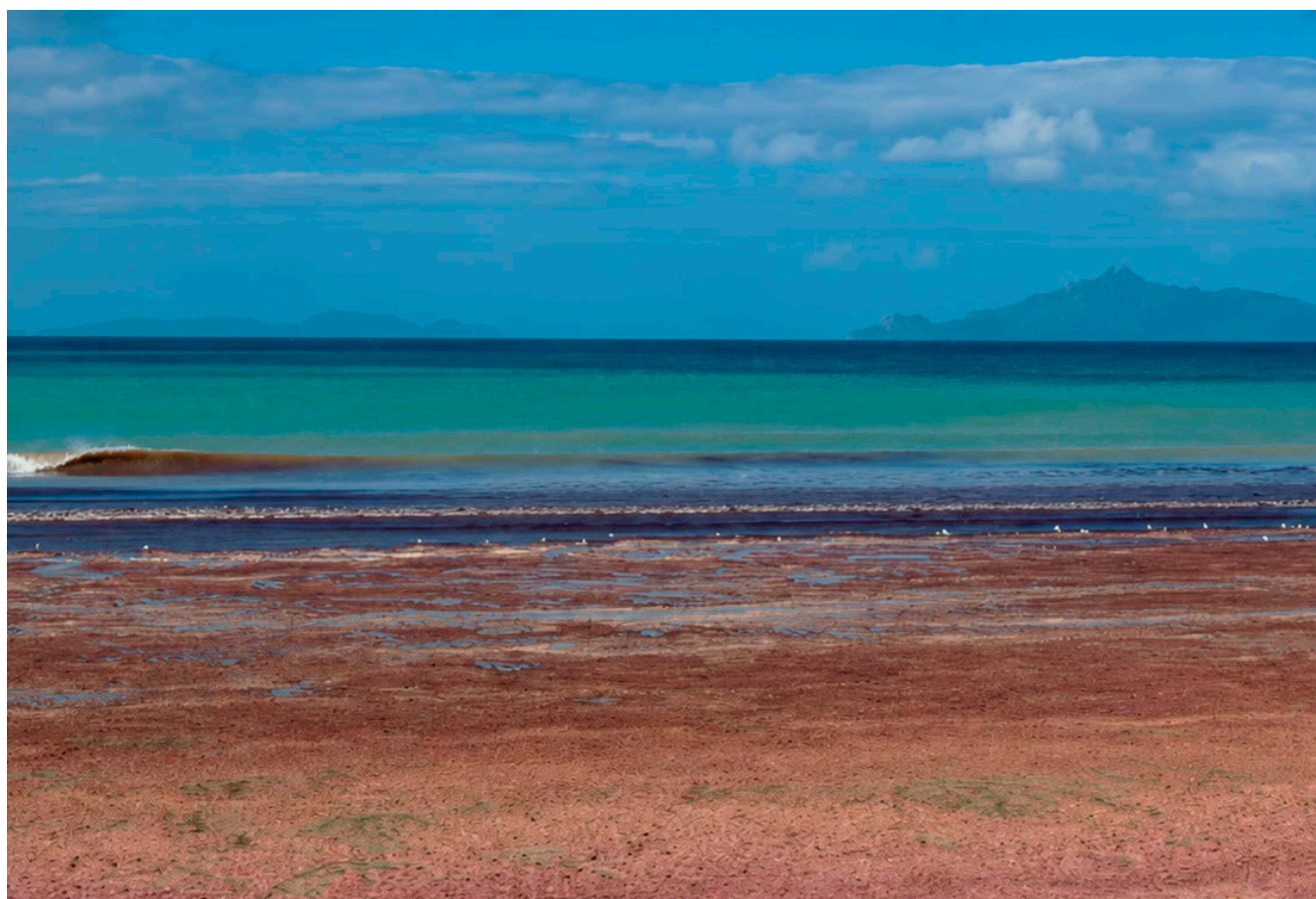
Exercise and training increase oxidative stress, inflammatory signalling, and metabolic demand in horses. Equine studies demonstrate that oxidative stress rises following high-intensity or prolonged exercise and can impair recovery and performance if not adequately managed (MacNicol *et al.*, 2018; Powers & Jackson, 2008).

- 🌿 Marine-derived antioxidants present in brown and red seaweeds contribute to redox balance, while improved hindgut fermentation enhances energy extraction efficiency without increasing dietary intake (Williams *et al.*, 2004; Zhang *et al.*, 2015).

Through combined effects on fermentation, immune tone, and oxidative balance, marine polysaccharide biology predicts:

- Improved stamina and metabolic efficiency
- Faster post-exercise recovery
- Greater resilience to cumulative training and environmental stress

Importantly, these effects arise indirectly through improved gut ecology and systemic balance, rather than through direct ergogenic stimulation.



WHY A MULTI-SEAWEED APPROACH CAN BE BIOLOGICALLY ADVANTAGEOUS IN HORSES

Functional Area	Brown-type Seaweeds (<i>Ascophyllum</i> -type)	Green-type marine polysaccharides	Red-type marine polysaccharides	Multi-seaweed blend
Hindgut microbiome & fermentation	✓	✓✓	✓	✓✓✓
Fibre utilisation & SCFA production	—	✓✓	✓	✓✓
Manure consistency & gut comfort	—	✓	✓✓	✓✓✓
Immune modulation / inflammatory tone	✓✓	✓	✓	✓✓✓
Behaviour & gut-brain axis*	—	✓✓	✓	✓✓
Hoof horn strength & quality	✓✓	—	✓	✓✓
Skin & coat condition	✓	—	✓	✓✓
Performance, recovery & resilience	✓	✓	✓	✓✓✓
Dose flexibility & mineral management	—	✓✓✓	✓✓✓	✓✓✓

Legend:

- ✓ = supporting or plausible contribution
- ✓✓ = established or well-supported contribution
- ✓✓✓ = primary or system-level contribution
- = not a reliable or consistent function at practical inclusion levels

Interpretation: In horses, hindgut fermentation sits upstream of behaviour, performance, and tissue integrity through its effects on microbial metabolism, SCFA production, immune tone and gut comfort.

Behavioural effects reflect modulation via fermentation-derived metabolites and gut comfort, not direct neurological action.

Note: Functional attributions reflect group-level properties of marine macroalgae and known polysaccharide biology. Tables do not imply disclosure of specific species composition, nor discrete clinical claims.



PATENTS, MECHANISM COHERENCE, AND THE CENTRAL ROLE OF GUT HEALTH IN MULTI-PURPOSE ANIMAL NUTRITION

HOW OCEANFEED'S PATENTED CONCEPTS REINFORCE THE SCIENCE AND OBSERVED OUTCOMES

Two granted patents underpin the development and application of **OceanFeed™**. While differing in scope, both are built around a **common mechanistic principle: that combinations of marine macroalgae can be used to beneficially influence gastrointestinal function and microbiota**, and that improvements in gut health subsequently manifest as improved performance, resilience, and health outcomes across species and life stages.

Rather than claiming isolated "effects", the patents codify a **systems-based nutritional approach**, where gut health is treated as the *primary lever* through which multiple downstream benefits are expressed. In the patents, improvements in performance, efficiency or output are presented as downstream consequences of microbiome modulation rather than as direct effects of the seaweed blend itself.

FROM FORMULATION CONCEPT TO BIOLOGICAL MECHANISM

At a high level, the patents describe the use of **multi-seaweed blends (brown, green, and red macroalgae)** at practical inclusion rates to:

- ✓ Modulate the gastrointestinal microbial ecosystem
- ✓ Improve digestive efficiency and barrier function
- ✓ Reduce inflammatory and oxidative load
- ✓ Enhance utilisation of nutrients already present in the diet

This framing is consistent with modern nutritional science, which increasingly recognises the gut not as a passive digestive tube, but as a **dynamic interface between diet, immunity, metabolism, and behaviour**.



Importantly, the patents do not rely on any single seaweed or any single bioactive compound. Instead, they reflect the understanding that **different seaweed groups contribute distinct but complementary polysaccharides and bioactives**, and that the combination is what enables reliable, repeatable outcomes.

ALIGNMENT WITH INDEPENDENT SCIENCE

Independent literature shows that:



Brown seaweeds provide fucoidans, laminarins, alginates, and phlorotannins that support immune modulation, epithelial integrity, antimicrobial balance, and keratinocyte function.



Green seaweeds supply highly fermentable rhamnose-rich polysaccharides that selectively stimulate fibrolytic and butyrate-producing bacteria, supporting hindgut fermentation and gut-brain signalling.



Red seaweeds contribute sulphated galactans and gel-forming fibres that stabilise gut hydration, support mucosal comfort, and provide potent antioxidant and anti-inflammatory activity.

The patents reflect this same division of labour at a conceptual level: **immune tone, microbial ecology, physical gut environment, and nutrient utilisation are addressed simultaneously rather than sequentially.**

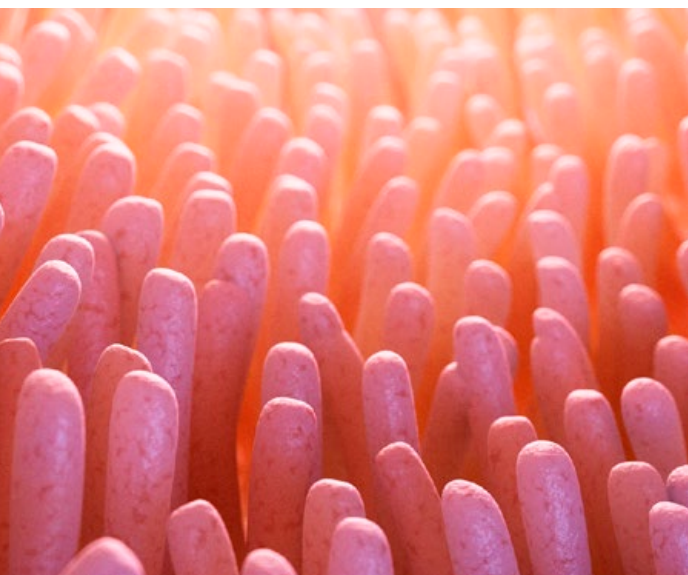
This is a critical distinction from many conventional feed additives, which are typically designed to act on a **single target** (e.g. toxin binding, acidification, mineral supplementation, or microbial suppression).

Recent reviews have highlighted that interaction between seaweed polysaccharides and polyphenols enhance colonic bioactivity, SCFA production and microbiome modulation, providing a mechanistic basis for multi-component marine formulations rather than isolated compounds (*Lee et al., 2023*).



WHY GUT HEALTH SITS UPSTREAM OF SO MANY “VISIBLE” BENEFITS

Across species, improvements in gut ecology have been associated with a wide range of downstream outcomes, depending on physiology and production context.



- ✓ Improved manure or stool consistency
- ✓ Calmer behaviour and improved trainability
- ✓ Enhanced coat, skin, and hoof quality
- ✓ Better recovery and resilience under stress
- ✓ Improved feed efficiency or growth
- ✓ Better egg production or egg quality
- ✓ Improved litter performance

The patents provide a useful framework for understanding *why* such diverse effects can stem from a single nutritional intervention.

The explanation lies in the **central role of the gut**:

- 1. Improved microbial balance** increases production of beneficial metabolites (e.g. short-chain fatty acids such as butyrate).
- 2. Improved barrier integrity** reduces immune activation driven by gut-derived antigens.
- 3. Lower inflammatory “background noise”** reduces energy and nutrient diversion away from productive functions.
- 4. More efficient nutrient extraction** improves utilisation of forage and concentrate without increasing intake.
- 5. Gut–brain signalling** improves comfort and behavioural stability.

From this perspective, improvements in hoof quality, behaviour, performance, or egg output are not separate effects — they are **downstream expressions of a healthier, more efficient gut environment**.

The patents formalise this logic:

Intervene at the level of gut ecology and allow the animal’s own physiology to express the benefits.

RELEVANCE TO HORSES: TRANSLATING THE SAME MECHANISM INTO EQUINE OUTCOMES

Horses are particularly sensitive to changes in gut health because:

- They rely heavily on hindgut fermentation for energy
- They are prone to dysbiosis, acidosis, and inflammatory gut responses
- Gut discomfort readily manifests as behavioural or performance issues
- Subclinical inflammation can impair hoof, skin, and recovery long before overt disease appears

From an equine perspective, the patented multi-seaweed concept explains why improvements in gut ecology can simultaneously support:

- ✓ Digestive consistency and manure quality
- ✓ Calmness and focus (via gut–brain pathways)
- ✓ Hoof horn strength and growth
- ✓ Coat and skin condition
- ✓ Respiratory comfort and immune resilience
- ✓ Performance and post-exercise recovery



Crucially, these outcomes do not require the seaweed to be “targeted” at each system individually but arise from stabilisation of hindgut fermentation, immune tone and nutrient utilisation.



A MULTI-PURPOSE NUTRITIONAL PLATFORM, NOT A SINGLE-PURPOSE ADDITIVE

The patents help frame **OceanFeed™** not as another narrowly defined additive, but as a **multi-purpose nutritional platform**.

Many widely used products are effective but limited in scope:

- A toxin binder binds toxins
- A yeast supports fermentation
- A mineral supplement supplies minerals
- A calming supplement targets behaviour
- A coat supplement targets appearance

OceanFeed™, by contrast, acts **upstream** — on gut ecology and function — allowing multiple systems to benefit simultaneously.

This distinction is important for veterinarians and nutritionists evaluating its role in feeding programmes. Rather than replacing targeted interventions where those are clearly indicated, **OceanFeed™** can be used as a **foundational support** that reduces the need for multiple single-purpose products and improves overall nutritional efficiency and resilience.

SUMMARY

The two patents reinforce a central and increasingly well-supported concept in animal nutrition:

Improving gut health is one of the most powerful ways to improve whole-animal performance, resilience, and wellbeing.

By formalising the use of **complementary brown, green, and red seaweeds** to influence gut microbiota, immune tone, and digestive efficiency, the patents provide an intellectual and mechanistic foundation that aligns closely with:

- ✓ Independent scientific literature
- ✓ Observed outcomes across multiple species
- ✓ Practical field experience in horses

Taken together, they support positioning **OceanFeed™** as a **versatile, science-led, multi-purpose nutritional tool**, rather than a single-effect supplement — a distinction that becomes increasingly important as equine nutrition moves toward integrated, gut-centred health strategies.

ALIGNMENT BETWEEN SCIENTIFIC PREDICTIONS AND OBSERVED OUTCOMES IN HORSES

These outcomes reflect representative observations from a combination of structured studies, field observations and commercial use under varied management conditions utilising Ocean Harvest Technology's proprietary blended seaweed feed additive **OceanFeed™**. They are field observations and are not presented as controlled equine trial outcomes.

✓ Significant increases in fibrolytic hindgut bacteria

Matching predictions for green and red seaweed fermentability.

✓ Reductions in potentially dysbiosis-associated taxa

Consistent with immune/mucosal support expected from brown + green.

✓ Noticeable improvement in hoof horn and coat condition

Matches the keratinocyte, antioxidant, and mineral roles of brown and red seaweeds.

✓ Calmer behaviour and improved focus

Fully aligned with SCFA–gut–brain pathways and reduced discomfort.

✓ Improved stool consistency and reduced digestive upset

Supported by red-seaweed gel-forming fibres and green prebiotics.

✓ Enhanced performance and faster recovery

Consistent with improved oxidative balance and reduced inflammatory load.

✓ Anecdotal improvements in comfort under environmental challenge e.g. fewer airway irritations have been observed

Consistent with broader immune/inflammatory modulation effects noted in the literature

Across the board, the **real-world results mirror the mechanistic predictions**, giving strong validity to multi-seaweed equine nutrition.

MANUFACTURING, FORMULATION, AND PRACTICAL CONSIDERATIONS FOR EQUINE FEED PRODUCERS

While the primary rationale for multi-seaweed nutrition in horses is biological, practical formulation and manufacturing considerations are also important for equine feed producers evaluating its use as a long-term ingredient.

Unlike companion animal diets, equine feeds are typically less processed, lower in fat, and fed at higher inclusion rates over extended periods. As a result, ingredient consistency, mineral management, and formulation flexibility are often of greater concern than processing functionality alone.

INGREDIENT CONSISTENCY AND SPECIFICATION CONTROL

Marine macroalgae are biologically variable raw materials. Single-seaweed products, particularly those derived from brown seaweeds, can show substantial natural variation in iodine (Teas *et al.* 2004), ash, and mineral content depending on harvest location, season, and processing method.

A multi-seaweed approach mitigates this risk by:

- distributing functional contribution across multiple macroalgal groups,
- reducing reliance on any single species,
- and allowing tighter specification control on iodine and total mineral load.

For equine feed manufacturers, this translates into improved batch-to-batch consistency and reduced formulation volatility, particularly in feeds intended for long-term use.

IODINE MANAGEMENT AND DOSE FLEXIBILITY

Horses are particularly sensitive to excessive iodine intake due to long-term feeding patterns and cumulative exposure (Teas *et al.* 2004; NRC 2007). *Ascophyllum*-only products can impose practical limits on inclusion rate because iodine content scales directly with dose.

By contrast, multi-seaweed formulations allow:

- lower reliance on iodine-rich brown seaweed fractions,
- greater functional contribution from green and red seaweed components,
- and improved dose flexibility without approaching iodine thresholds.

This enables manufacturers to formulate feeds that deliver biological benefit without constraining mineral balance or requiring compensatory formulation adjustments.

INTEGRATION INTO EXISTING EQUINE FEED FORMATS

Multi-seaweed ingredients are compatible with common equine feed formats, including:

- compound feeds,
- balancers,
- pelleted and textured feeds,
- and supplementary top-dress products.



At typical inclusion levels, they do not typically alter palatability, physical structure, or feeding behaviour in most formulations when correctly incorporated. This allows manufacturers to incorporate gut-centred functionality without reformulating entire product lines or compromising existing feed characteristics.

LONG-TERM FEEDING AND PROGRAMME STABILITY

Equine feeding programmes often prioritise stability and consistency over rapid short-term effects. Products intended for daily feeding must therefore demonstrate suitability for long-term inclusion.

By acting upstream on gut ecology rather than targeting isolated symptoms, multi-seaweed formulations are well suited to:

- continuous feeding,
- varied management conditions,
- and horses with differing workloads and stress exposure.

For manufacturers, this supports positioning such ingredients as foundational nutritional components rather than seasonal or problem-specific additives.

QUALITY ASSURANCE AND REGULATORY POSITIONING

From a regulatory and quality perspective, multi-seaweed ingredients benefit from:

- alignment with established feed material categories,
- avoidance of pharmacological or drug-like positioning,
- and reliance on nutritional and physiological support rather than claims-based outcomes.

This allows equine feed manufacturers to position products confidently within existing regulatory frameworks while still offering meaningful functional differentiation.

SUMMARY FOR EQUINE FEED MANUFACTURERS

For equine feed producers, the relevance of multi-seaweed nutrition extends beyond biological theory. Practical advantages include:

- ✓ improved formulation flexibility,
- ✓ reduced iodine and mineral risk,
- ✓ consistent long-term feeding suitability,
- ✓ and the ability to deliver gut-centred functional support without increasing product complexity



When integrated thoughtfully, multi-seaweed ingredients can enhance both the nutritional robustness and commercial resilience of equine feed products.

CLINICAL IMPLICATIONS FOR EQUINE PRACTICE

Based on both scientific mechanisms and observed outcomes, equine vets and nutritionists should consider multi-seaweed supplementation when supporting:

- Horses with digestive irregularities
- Horses with behavioural tension or anxiety
- Horses requiring improved hoof/coat quality
- Performance or endurance horses
- Horses in recovery or rehabilitation
- Horses prone to metabolic or inflammatory challenges
- Animals under stress (transport, competition, environmental changes)

The physiology is consistent, the mechanisms well-understood, and the evidence from multiple animal models aligns closely with what is observed in horses.

Multi-seaweed nutrition represents a scientifically robust evolution beyond brown seaweed-only supplementation.

For horses, the combination of brown, red, and green macroalgae delivers complementary benefits to digestion, immunity, behaviour, tissue integrity, and overall performance that no single seaweed can achieve alone.

As with any nutritional intervention, outcomes depend on baseline diet, management, health status, and environmental factors. **OceanFeed™** is intended as foundational nutritional support rather than a replacement for targeted veterinary interventions where clinically indicated.



APPENDIX – INDEPENDENT SCIENTIFIC REFERENCES

A. EQUINE-SPECIFIC & LARGE-HERBIVORE RESEARCH

This section summarises independent scientific literature underpinning the central role of hindgut microbial fermentation in equine health, comfort, and resilience. References are grouped to distinguish foundational physiological studies, modern microbiome research, and integrative disease-relevant evidence.

A1. Foundational Hindgut Fermentation Physiology

This study established where fermentation occurs in the equine gastrointestinal tract and how diet influences fermentation patterns.

- De Fombelle, A. et al. (2003).

Characterization of the microbial and biochemical profile of the different segments of the digestive tract in horses given two distinct diets. *Animal Science*, 77(2), 293–304.

→ Demonstrates segment-specific distribution of anaerobic and cellulolytic bacteria, volatile fatty acids, lactic acid, and pH, confirming the hindgut as the primary site of microbial fermentation and showing diet-dependent shifts in fermentation profiles.

A2. Hindgut Microbiome Composition & Dietary Modulation

These studies define the microbial taxa responsible for fibre degradation and SCFA production in the equine hindgut, and how dietary inputs modulate community structure.

- Curadi, M et al. (2025).

Characterisation of the fecal microbiome in Arabian horses under controlled management conditions. *Journal of Equine Science*, 12, 309.

→ Provides modern confirmation of core hindgut microbiome features using contemporary sequencing tools, reinforcing the relevance of microbial diversity and fibrolytic dominance.

- Dougal, K. et al. (2012).

Identification of a core bacterial community within the equine hindgut. *Applied and Environmental Microbiology*, 78(10), 3440–3444.

→ Identifies a conserved core hindgut microbiome dominated by fibrolytic and saccharolytic bacteria essential for fibre fermentation.

- Garber, A. et al. (2020).

Equine gut microbiota responses to dietary and management factors. *Frontiers in Veterinary Science*, 7, 558.

→ Highlights environmental and dietary drivers of microbial variability.

- Julliand, V. and Grimm, P. (2016).

The microbiome of the horse hindgut: history and current knowledge. *Animal*, 10(10), 1607–1616.

→ Authoritative review of equine hindgut microbial ecology, fermentation pathways, and dietary influences.

- Kauter, A. et al. (2019).

Dietary influence on the fecal microbiota of horses revealed by 16S rRNA sequencing. *Journal of Equine Veterinary Science*.

→ Demonstrates diet-dependent shifts in microbial composition using sequencing-based approaches.

- Park, T. et al. (2021).

Fecal microbiota structure and functional implications in horses. *Animals*, 11, 1049.

→ Links microbial diversity with fermentation efficiency and gut health indicators.

- **Schoster, A. et al. (2012).**

Presence and molecular characterization of *Clostridium difficile* and *Colstridium perfringens* in intestinal compartments of healthy horses. *BMC Veterinary Research*, 8, 94

→ Provides contextual evidence for microbial compartmentalisation.

- **Steelman, S.M. et al. (2012).**

Pyrosequencing of 16S rRNA genes in fecal samples reveals high diversity of hindgut microflora in horses and potential links to chronic laminitis. *BMC Veterinary Research*, 8, 231.

→ Provides early next-generation sequencing data describing equine hindgut microbial diversity and structure.

- **Wunderlich, C.M. et al. (2023).**

Microbial fibre degradation and metabolic pathways in the equine hindgut. *Animal Microbiome*, 5, 18.

→ Provides detailed insight into fibre-degrading microbial networks and SCFA production pathways in horses.

A3. Microbiome, Fermentation Imbalance & Colic Risk

These studies integrate microbiome composition, fermentation metabolites, and health outcomes.

- **Lara, F. et al. (2022).**

Changes in the gut microbiome and colic in horses: Are they causes or consequences? *Open Veterinary Journal*, 12(2), 242–249.

→ Integrative review linking dietary modulation, microbial dysbiosis, altered SCFA profiles, and colic risk.

- **Yano, R. et al. (2025).**

Correlation of hindgut microbiome and fermentation properties with a history of gas and/or impaction colic in Japanese draft horses. *Journal of Equine Science*, 36(3), 93–102.

→ Demonstrates reduced microbial evenness, depletion of fibrolytic taxa, increased *Streptococcus* abundance, and elevated fecal lactate in horses with prior colic, under identical diets.

A4. Microbiome–Gut–Brain Interactions

- **Bulmer, L. et al. (2015).**

The effects of a high-starch or high-fibre diet on equine reactivity and handling behaviour. *Applied Animal Behaviour Science*, 165, 95–102.

→ Demonstrates that diet composition (high-starch vs high-fibre) influences behavioural reactivity and physiological stress responses in horses.

- **Bulmer, L. et al. (2019).**

High-starch diets alter equine faecal microbiota and increase behavioural reactivity. *Scientific Reports*, 9(1), 18621.

→ Shows diet-induced alterations in hindgut microbiota structure correlated with increased behavioural reactivity, supporting a microbiota–gut–brain association.

- **Destrez, A. et al. (2019).**

Dietary-induced modulation of the hindgut microbiota is related to behavioural responses during stressful events in horses. *Physiology & Behavior*, 199, 94–102.

→ Links diet-driven microbial shifts to behavioural stress responses, supporting the functional relevance of the microbiota–gut–brain axis in horses.

- **Frape, D. (2010).**

Equine Nutrition and Feeding, Wiley-Blackwell.

→ Provides nutritional and management context for digestive comfort and behavioural stability in horses.

- **Homer, B. et al. (2023)**

Gut Microbiota and Behavioural Issues in Production, Performance and Companion Animals: A Systematic Review, *Animals*, 13, 1458

→ Systematic review synthesising evidence linking gut microbiota composition and behavioural phenotypes, supporting biological plausibility of microbiota-gut-brain interaction.

- Mach, N. et al. (2020).

Priming for welfare: gut microbiota is associated with equitation conditions and behaviour in horse athletes. *Scientific Reports*, 10, 13286

→ Demonstrates associations between microbiota and behavioural indicators in horses.

A5. Immune Function, Inflammation & Gut Integrity in Horses

- Costa, M.C. et al. (2012).

The equine intestinal microbiome. *Animal Health Research Reviews*, 13(1), 121–128.

→ Foundational review linking gut microbial ecology to health and immune interactions.

- MacNicol, J.L. et al. (2018).

A time-course evaluation of inflammatory and oxidative markers following high-intensity exercise in horses: a pilot study. *Journal of Applied Physiology*, 124(4), 860–865.

→ Demonstrates systemic inflammatory and oxidative responses to exercise stress in horses.

- Stewart, A.S., Pratt-Phillips, S., Gonzalez, L.M., & Holcombe, S.J. (2017).

Alterations in intestinal permeability : the role of the “leaky gut” in equine health and disease, *Journal of Equine Veterinary Science*, 52, 10-22

A6. Hoof, Skin & Keratinised Tissue Health in Horses

- Miller, W.H., et al. (2013).

Small Animal *Equine Dermatology*, Saunders-Elsevier.

→ Veterinary text linking nutrition, inflammation, and skin health.

- Pollitt, C.C. (2010).

Equine laminitis and hoof horn biology. *Veterinary Clinics of North America: Equine Practice*.

→ Foundational review on hoof keratinocyte biology and systemic influences.

These references support the relevance of marine bioactives influencing keratinocyte activity and inflammatory tone.

B. MARINE POLYSACCHARIDES & SEAWEED BIOACTIVES

RELEVANT TO HORSES AND OTHER HERBIVORES

These studies are not equine-exclusive but describe mechanisms directly applicable to equine physiology.

- O’Sullivan, L. et al. (2010).

Prebiotics from marine macroalgae for human and animal health applications. *Marine Drugs*, 8(7), 2038–2064.

→ Widely cited review framing marine polysaccharides explicitly as functional dietary fibres.

- Xie, C. et al. (2023).

A Review on Seaweeds and Seaweed-Derived Polysaccharides: Nutrition, Chemistry, Bioactivities and Applications. *Food Reviews International*, 40, 1312-1347.

→ Comprehensive review of macroalgal polysaccharides, polyphenols and antioxidant compounds supporting their relevance to gut health and systemic physiology.

B1. Prebiotic Fermentation, SCFA Production & Microbiome Modulation

- Charoensiddhi, S. et al. (2022).

Gut microbiome modulation and gastrointestinal digestibility of polysaccharide-enriched seaweed extracts. *Journal of Functional Foods*, 96, 105204.

→ Demonstrates resistance to upper-GI digestion, selective fermentation by gut microbiota and significant increases in total SCFAs and butyrate production

- **Cherry, P. et al. (2019).**

Marine polysaccharides as prebiotics. *Critical Reviews in Food Science and Nutrition*, 59(1), 1–13.

→ Reviews fermentability of marine polysaccharides across monogastric and herbivorous species.

- **Han, Z.-L. et al. (2019).**

Evaluation of prebiotic potential of three marine algae oligosaccharides from enzymatic hydrolysis. *Marine Drugs*, 17, 173.

→ Demonstrates selective stimulation of butyrate-producing taxa and increased SCFA production

- **Leiro, J.M. et al. (2007).**

Immunomodulatory activity of sulphated polysaccharides from *Ulva* spp. *International Immunopharmacology*, 7(7), 879–888.

→ Demonstrates suppression of LPS-induced inflammatory signalling by ulvan-type polysaccharides.

- **Seong, H., Bae, J.-H., Seo, J.-S., Kim, S.-A., Kim, T.-J., & Han, N.-S. (2019).**

Comparative analysis of prebiotic effects of seaweed polysaccharides laminaran, porphyran, and ulvan using in vitro human fecal fermentation. *Journal of Functional Foods*, 57, 408–416

→ Demonstrates selective stimulation of fibrolytic and butyrate-producing taxa.

B2. Intestinal Barrier Integrity, Permeability & Mucosal Protection

- **Yao, W. et al. (2023).**

Polysaccharides from brown seaweed: physicochemical properties, intestinal absorption and beneficial effects on the intestinal barrier. *Food Frontiers*, 4, 1547–1560.

- **Zhu, Z. et al. (2021).**

Effects of sulphated galactans from red seaweeds on short-chain fatty acid production and gut microbial activity. *Food Hydrocolloids*, 112, 106320.

→ Supports SCFA production and fermentative effects of red seaweed galactans.

B3. Immune Modulation, Barrier Function & Tissue Integrity

- **Ale, M.T. et al. (2011).**

Anti-inflammatory activities of fucoidans from brown seaweeds. *Carbohydrate Polymers*, 85(3), 641–647.

→ Provides direct evidence for anti-inflammatory effects of brown seaweed fucoidans.

- **Chen, Y et al. (2019).**

Fucoidan from *Undaria pinnatifida* Ameliorates Epidermal Barrier Disruption via Keratinocyte Differentiation and CaSR Level Regulation. *Marine Drugs*, 17, 660.

→ Demonstrates fucoidan-mediated enhancement of keratinocyte differentiation and epidermal barrier function in vitro.

- **Fitton, J.H. et al. (2015).**

Fucoidan: a review of biological activities and therapeutic potential. *Marine Drugs*, 13, 5920–5946.

- **Song, Y.S. et al. (2014).**

Fucoidan Promotes the Reconstruction of Skin Equivalents. *Korean Journal of Physiology & Pharmacology*, 18(4), 327–331.

→ Demonstrates mechanistic support for tissue integrity roles.

B4. Polysaccharide-Polyphenol Interactions and Gut Modulation

- Lee, Z.J. et al. (2025).

Unravelling the bioactive interplay: seaweed polysaccharide, polyphenol and their gut modulation effect. *Critical Reviews in Food Science and Nutrition*, 65(2), 382-405.

→ Comprehensive review describing how interactions between seaweed polysaccharides and polyphenols enhance colonic delivery, SCFA production, microbiome modulation and anti-inflammatory effects.

- Lin, Q. et al. (2025).

Seaweed polysaccharides as potential Prebiotics: Rationale, factors, Prebiotic activity manifestations, gut health mechanisms and extraintestinal impacts. *Trends in Food Science & Technology*, 163, 105202.

→ High-level review describing structure–function relationships of seaweed polysaccharides, their interaction with gut microbiota, SCFA production, and downstream effects on barrier integrity and immune signalling.

B5. Structural Diversity, Bioaccessibility & Species Variability

- Pandey, A. et al. (2022)

Variability in macroalgal polysaccharide composition and functional implications. *Journal of Cleaner Production*, 363, 132456

→ Demonstrates that polysaccharide structure, molecular weight and sulfation patterns vary widely across species and conditions influencing fermentability and biological activity.

- Zaitseva, O.O., Sergushkina, M.I., Khudyakov, A.N., Polezhaeva, T.V., & Solomina, O.N. (2022).

Seaweed sulfated polysaccharides and their medicinal properties. *Algal Research*, 68, 102885.

B6. Ruminant & Cross-Species Fermentation Context

- Ahmed, M. et al. (2022).

Effects of brown seaweed supplementation on rumen fermentation and microbial ecology. *Fermentation*, 8, 504.

→ Demonstrates fermentation shifts, SCFA modulation, and microbial restructuring in large-herbivore systems.

- You, L. et al. (2020).

Brown seaweed polysaccharides: structure–function relationships in gut fermentation. *International Journal of Food Science and Technology*, 55, 1199-1206

→ Explains how molecular weight and sulfation influence fermentability and microbiome outcomes.

C. OXIDATIVE STRESS, PERFORMANCE & RECOVERY (EQUINE-RELEVANT)

- Finaud, J. et al. (2012).

Oxidative Stress. *Sports Medicine*, 36, 327-358.

- Michalak, I. et al. (2022)

Antioxidant effects of seaweeds and their active compounds on animal health and production – a review. *Veterinary Quarterly*, 42, 1, 48-67.

→ Reviews antioxidant mechanisms of seaweed-derived compounds and their relevance to oxidative balance, stress tolerance and health across animal production systems.

- Powers, S.K. & Jackson, M.J. (2008).

Exercise-induced oxidative stress: cellular mechanisms and impact on performance. *Physiological Reviews*, 88, 1243–1276.

→ Supports antioxidant relevance to equine recovery and stamina.

- Williams, C.A. et al. (2004).

Antioxidant supplementation and oxidative stress in exercising horses. *Journal of Nutrition*, 134(8), 2081S–2084S.

→ Supports the relevance of antioxidant support during exercise and recovery.

D. GUT–BRAIN AXIS & SYSTEMIC EFFECTS (CROSS-SPECIES, HIGHLY RELEVANT)

- Cryan, J.F. & Dinan, T.G. (2012).

Mind-altering microorganisms: the impact of the gut microbiota on brain and behaviour. *Nature Reviews Neuroscience*, 13, 701–712.

- Dalile, B. et al. (2019).

The role of short-chain fatty acids in microbiota–gut–brain communication. *Frontiers in Neuroscience*, 13, 134.

- Pluske, J.R. et al. (2018).

Feed- and feed-additive-related aspects of gut health and development in animals. *Journal of Animal Science and Biotechnology*, 9, 1–16.

→ Positions gut health as the central integrator of nutrition, immunity, and performance across species.

E. MULTI-SEAWEED & SYNERGISTIC APPROACHES

- Pereira, L. & Valado, A. (2025).

Beyond Nutrition: The Therapeutic Promise of Seaweed-Derived Polysaccharides Against Bacterial and Viral Threats. *Marine Drugs*, 23(10), Article 407.

- Tanna, B. & Mishra, A. (2018).

Metabolites from seaweeds and their applications. *Journal of Applied Phycology*, 30, 1815–1828.

F. PRACTICAL FORMULATION & LONG-TERM FEEDING CONSIDERATIONS

- Teas, J. et al. (2004).

Variability of iodine content in seaweed and implications for dietary intake. *Journal of Food Composition and Analysis*, 17(3–4), 421–432.

→ Demonstrates large natural variation in iodine content across seaweeds.

- National Research Council (2007).

Nutrient Requirements of Horses. *National Academies Press*.

→ Authoritative reference on mineral tolerance, long-term feeding, and dietary balance in horses.

G. WHY THESE REFERENCES MATTER FOR EQUINE NUTRITION

Collectively, these studies support the core claims of the equine white paper:

- Hindgut fermentation quality underpins behaviour, performance, and health
- Immune tone and inflammation strongly influence recovery and tissue integrity
- Green and red seaweeds provide prebiotic and stool-stabilising functions beyond brown seaweeds alone
- Marine antioxidants support performance resilience
- A multi-seaweed approach better reflects equine digestive physiology than single-species supplementation