CARBON-KAI LTD

Carbon-Kai in Livestock Systems

An Introduction to the Science & Agricultural Potential

What is Carbon-Kai?

Carbon-Kai is made from Carbon Coated Minerals (CCM), engineered specifically for ruminal efficiency, developed by Carbon-Kai Ltd. Carbon-Kai incorporates a purposeful blend of minerals into pine biomass before precise pyrolysis. This produces a carbon-mineral composite engineered to deliver specific outcomes in the rumen and digestive system of cattle and sheep, and to function across multiple biological systems on a farm: rumen fermentation, gut health, soil biology, and greenhouse gas (GHG) emissions.

Key distinction from biochar:

Standard biochar is produced from a single feedstock and is not optimised for rumen-specific function. Biochar can be made from multiple feedstocks at so many different temperatures and at different heat residence times. They all look like a biochar, but no two biochars are the same, and so many studies have been naively carried out with biochars that were never going to have positive results — harming biochar's reputation.

Carbon-Kai's mineral co-formulation modifies the surface chemistry and internal pore architecture to target rumen methanogenesis and digestive performance — distinguishing it from both first-generation biochars and post-production activated carbons used in existing peer-reviewed trials.

Why Does This Matter for Agriculture?

Methane from enteric fermentation is New Zealand’s single largest source of agricultural greenhouse gas emissions. It is also an energy loss for the animal — every litre of methane expelled is energy that could instead become milk fat, milk protein, or body weight. Carbon-Kai targets this inefficiency at its biological root, aiming to simultaneously reduce methane emissions and improve productive output.

How Does Carbon-Kai Work?

Carbon-Kai is designed to engage four distinct scientific mechanisms within the rumen:

1. Electron Storage & Transfer

Carbon-Kai’s engineered conductive surfaces act as alternative electron acceptors and transfer media, diverting electrons away from methane production toward more productive fermentation pathways.

2. Alternative Sinks for Electrons & Hydrogen

Methane production is the rumen’s primary mechanism for disposing of excess electrons and hydrogen. Carbon-Kai’s mineral components offer alternative sinks, ideally redirecting these toward volatile fatty acids (VFAs) the animal can use for milk and meat production.

3. Altering Microbial Communities

Carbon-Kai particles provide colonisable surfaces that support beneficial microbes while suppressing methane-producing archaea. Published dairy cattle trials using activated carbon showed a 30% reduction in methanogenic flora with increased non-methanogenic species diversity.

4. Chemical Concentration Modulation

The high surface area of Carbon-Kai adsorbs hydrogen and other metabolites, buffering rumen fluid concentrations and smoothing out metabolic fluctuations that would otherwise reduce fermentation efficiency.

The Cascading Benefits Pathway

- Manufacturing: Radiata pine biomass is converted into stable Carbon Coated Minerals (CCM), locking carbon that would otherwise return to the atmosphere as CO_2.
- Fed to cows: Modulates rumen fermentation, with internal in vitro trials indicating a 40–47% reduction in enteric CH_4 — quantum to be confirmed in the September 2026 in vivo trial.
- Gut transit: Adsorbs toxins, heavy metals, mycotoxins, and parasites during passage through the digestive system.
- In manure storage: Reduces ammonia (NH_3) and nitrous oxide (N_2O) losses during storage and field application.
- In pasture soil: Long-term carbon sequestration; improves soil fertility and water retention; reduces nitrate leaching into waterways.

Animal Health Benefits

- Gut health: Adsorption of mycotoxins, bacterial toxins, ammonia, heavy metals, dioxins, glyphosate, and PAHs before systemic absorption.
- Pathogen suppression: Reduction of harmful bacteria including C. botulinum, E. coli, Salmonella enterica, and Campylobacter jejuni.
- Internal parasite reduction: Evidence of reduced worm burden, with potential to reduce chemical worming requirements.
- Improved weight gains: Reported across cattle, pigs, goats, sheep, and poultry — most pronounced in pasture-based or nutritionally variable conditions.

Relevance to New Zealand

- Enteric CH_4 is NZ’s largest agricultural emission source and a primary target of the He Waka Eke Noa framework.
- N_2O from ruminant urine patches is a significant NZ-specific GHG source. Biochar has shown >50% reduction in N_2O flux from urine patches in NZ pasture research.
- Nitrate leaching into waterways is a primary environmental concern for NZ dairy farming. NZ field trials have reported significantly reduced topsoil nitrate-N concentrations following biochar application.
- Carbon-Kai contains no halogenated compounds or added nitrates — avoiding contamination concerns for milk, meat, or water supplies.
- The feed-through carbon sequestration model is compatible with NZ’s pasture-based grazing systems and manure application practices.

Carbon-Kai: Evidence Summary Table

Compiled from Carbon-Kai Scientific Evidence Review, September 2026

Benefit	Proposed Mechanisms	Effect Size / Outcome
ENTERIC METHANE REDUCTION		
Enteric methane reduction	Activated carbon provides high surface area for microbes; more efficient redox reactions via direct electron transfer.	Up to 62% reductions in methane production
Enteric methane reduction	As above + suppression of methanogenic archaea.	30–40% reduction in CH_4 (milking shed measurements), 180-head dairy herd, activated carbon at 0.5% DMI
Enteric methane reduction	Biofilm formation, altering rumen fermentation, microbial community, methane absorption, increased methanotrophs, alternative hydrogen sinks.	9.5% and 12% reduction at ~0.6% and ~2.4% DMI (controlled chamber trial); no significant effect in outdoor herd trial.
Enteric methane reduction	Conductive surfaces for microbes; more efficient redox reactions via direct electron transfer. Additional surfaces, redox functionality, and potential acceptors of electrons/hydrogen from mineral additions.	9.3% (steer sample) and 25% (bull sample) less CH_4 vs. reference activated carbon; reference AC achieved up to 62% reduction vs. control in vitro.
Methanogen population reduction	Shift in rumen/manure microbial community away from methanogenic archaea.	~30% reduction in methanogenic flora; relative increase in non-methanogenic species; significant increase in species richness and abundance.
MILK PRODUCTIVITY		
Milk volume increase	Rumen energy reallocation — methane energy redirected to more productive pathways.	+3.43% daily milk production
Milk protein increase	Improved rumen fermentation efficiency.	+2.63% milk protein
Milk fat increase	Improved rumen fermentation efficiency.	+6.32% milk fat
Body weight / feed efficiency gains	Toxin adsorption; improved gut health; more efficient digestion; more efficient redox reactions via direct electron transfer; biofilm formation.	Improved weight gains reported; effect most pronounced where diet quality is variable or toxin-impacted.
ANIMAL HEALTH		
Gut health & toxin adsorption	High surface area adsorbs mycotoxins, bacterial toxins, ammonia, heavy metals, pesticides, PAHs in digestive tract.	Reduced bioavailability of harmful substances; liver, kidney and immune protection reported.
Pathogen suppression	Shift in gut microbiome away from disease-causing species.	Suppression of C. botulinum, E. coli, Salmonella enterica, Campylobacter jejuni reported across multiple animal species.
Internal parasite reduction	Mechanism not clear; adsorption proposed.	Reduced worm burden in treated animals reported in a small number of publications; many anecdotal accounts.
SOIL & PASTURE		
Soil carbon sequestration	Feed-through pathway — biochar passes intact through digestive system into manure, applied to pasture.	70–90% of ingested biochar recovered intact in manure; condensed aromatic carbon structures confirm long-term stability.
Soil fertility & nitrate leaching reduction	Biochar increases CEC, water retention, nutrient retention, microbial diversity; adsorbs nitrate.	Major increase in soil carbon; significant reduction in topsoil nitrate-N concentrations at high application rate (NZ field trial).
WHOLE-FARM GREENHOUSE GAS		
Nitrous oxide (N_2O) reduction	Biochar increases nosZ-gene prevalence in soil microbiome — terminal reduction of N_2O to inert N_2; biochars provide porosity, surface areas, cation exchange capacity and increase pH.	Nitrous oxide flux from ruminant urine patch reduced by >50% (NZ pasture context). Meta-analyses: N_2O emissions reduction 19–38%, though one meta-analysis concluded this can decline rapidly after first year.
Ammonia (NH_3) reduction — manure storage	Biochar cover adsorbs NH_3 from manure surface; acid-activated biochar enhances effect.	37–51% NH_3 reduction (first month), 25–28% over four months; 72–80% headspace NH_3 reduction with 600°C biochar. Effect is biochar-type specific.