Eco-Eff TM

Grain Fusion and Mineral Architecture: A New Paradigm in Lipid Stability and Nutritional Efficiency

A biotechnological revolution in animal feed protection

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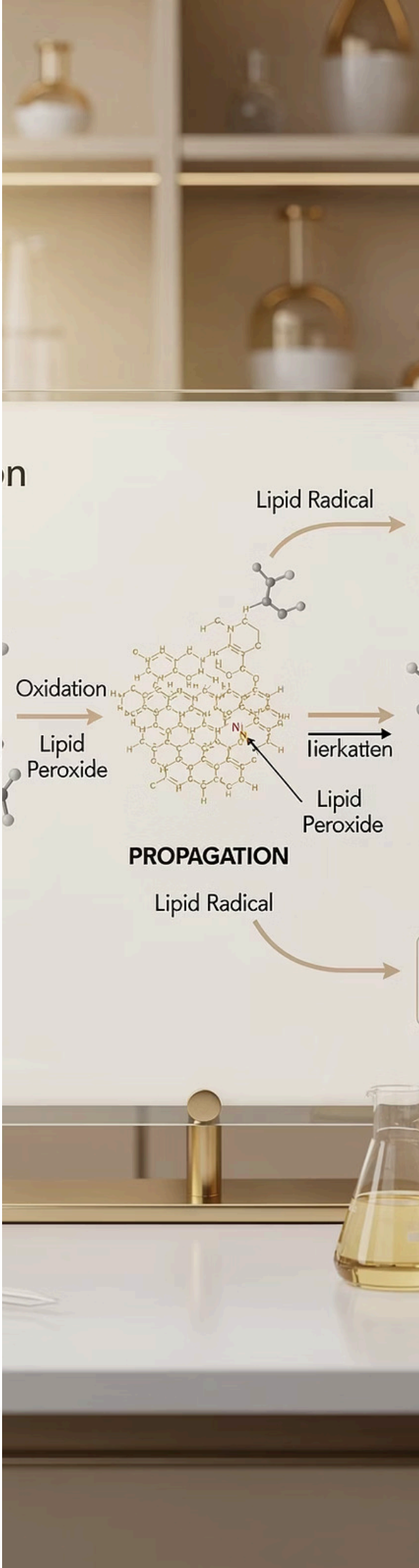
The Critical Challenge of Lipid Oxidation in Modern Animal Nutrition

The Central Problem

Oxidative stability is a strategic pillar of profitability in intensive animal production.

In the ecosystem of intensive animal production, oxidative stability exerts a functional hegemony not only over feed shelf life, but also as a strategic pillar of profitability and physiological integrity. Lipid degradation is a multivariate process that severely compromises palatability, inducing organoleptic rejection of the feed.

The most serious underlying risk is nutritional loss due to the destruction of fat-soluble vitamins (A, D, E, K) and the formation of malondialdehyde (MDA), a cytotoxic compound that erodes intestinal health. Under conditions of productive stress (heat, humidity, and metallic catalysts), conventional chemical antioxidation strategies are overwhelmed.



Critical Phases of Lipid Degradation

The degradation of unsaturated fatty acids breaks down into three critical phases that perpetuate the biological deterioration of food:

Initiation Propagation Termination

This process illustrates the chemical sequence of lipid deterioration in foods, from the initial formation of free radicals to the creation of compounds that cause rancidity.

Initiation

Extraction of a hydrogen atom from the lipid chain to form free radicals, activated by transition metals, UV light, or thermal stress

Propagation

Reaction of radicals with molecular oxygen to generate peroxides, which in turn attack other fatty acids, perpetuating the chain reaction

Termination

Interaction of radicals to form stable compounds (aldehydes, ketones, alcohols), responsible for rancidity and biological deterioration

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The Innovation of "Grain Fusion": Process Engineering vs. Conventional Mixing

"Grain Fusion" (Single Grain) transcends the mere mixing of ingredients to stand as a biotechnological disruption. Through mechano-chemical structural activation, the mineral morphology is modified to provide superior functionality.

Extreme micronization (range of 7-15 microns) and the elevation of specific surface area to **200-300 m²/g** redefine the capacity for interaction with the feed matrix.

7-15 µm

Extreme micronization range

200-300 m²/g

Specific surface area achieved

Grain Fusion

Mechanochemical Activation

Modifies mineral structure

Extreme Micronization

Particles 7–15 µm

High Specific Surface Area

200–300 m²/g

Improved Feed Interaction

Greater adhesion and mixing

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Water Activity Control: The Critical Zone

This vast specific surface area is the critical determinant for massive moisture sequestration, allowing a reduction in water activity (aw) to a range of 0.3 to 0.6. This interval is biochemically vital, as it represents the "zone of maximum enzymatic and oxidative rate"; by stabilizing aw at this point, the system's reactivity is neutralized before the degradation cascade begins.

Unique Grain Fusion Technology

Total homogeneity of active ingredients; prevents segregation and ensures thermal stability in granulation

Micronization (7-15 µm)

Optimization of rheological fluidity and colloidal coverage of fat droplets

Specific Surface Area (200-300 m²/g)

Massive moisture adsorption, controlling aw in the critical reactivity zone

Microencapsulation Engineering

Creation of a structural shield that blocks oxygen and metal ions

Functional Synergy of the Self-Stabilizing System ($NaHCO_3$ + SiO_2)

The Eco-Eff TM architecture bases its superiority on a dual system that simultaneously acts as a chemical regulator and a biophysical barrier.

Chemical Protection

$NaHCO_3$ neutralizes protons (H^+) released in the initial phases of oxidation. It maintains a slightly alkaline environment (pH 7.2-7.8), reducing the oxidative rate by **35%**.

Physical Protection

Micronized SiO_2 exerts a colloidal "microencapsulation." It forms a microscopic layer around lipids, creating an effective physical block against atmospheric oxygen.

> The neutralization reaction is expressed by:

$$NaHCO_3 + H^+ \rightarrow Na^+ + H_2O + CO_2$$

The scientific validation of this interaction is quantified through the **Synergy Index (SI)**:

$$IS = \frac{E(NaHCO_3 + SiO_2)}{E(NaHCO_3) + E(SiO_2)}$$

With SI values between **1.4 and 1.8**, the technology demonstrates that the enhanced components exceed the efficacy of isolated ingredients by 80%, consolidating a highly efficient inorganic self-stabilizing system.

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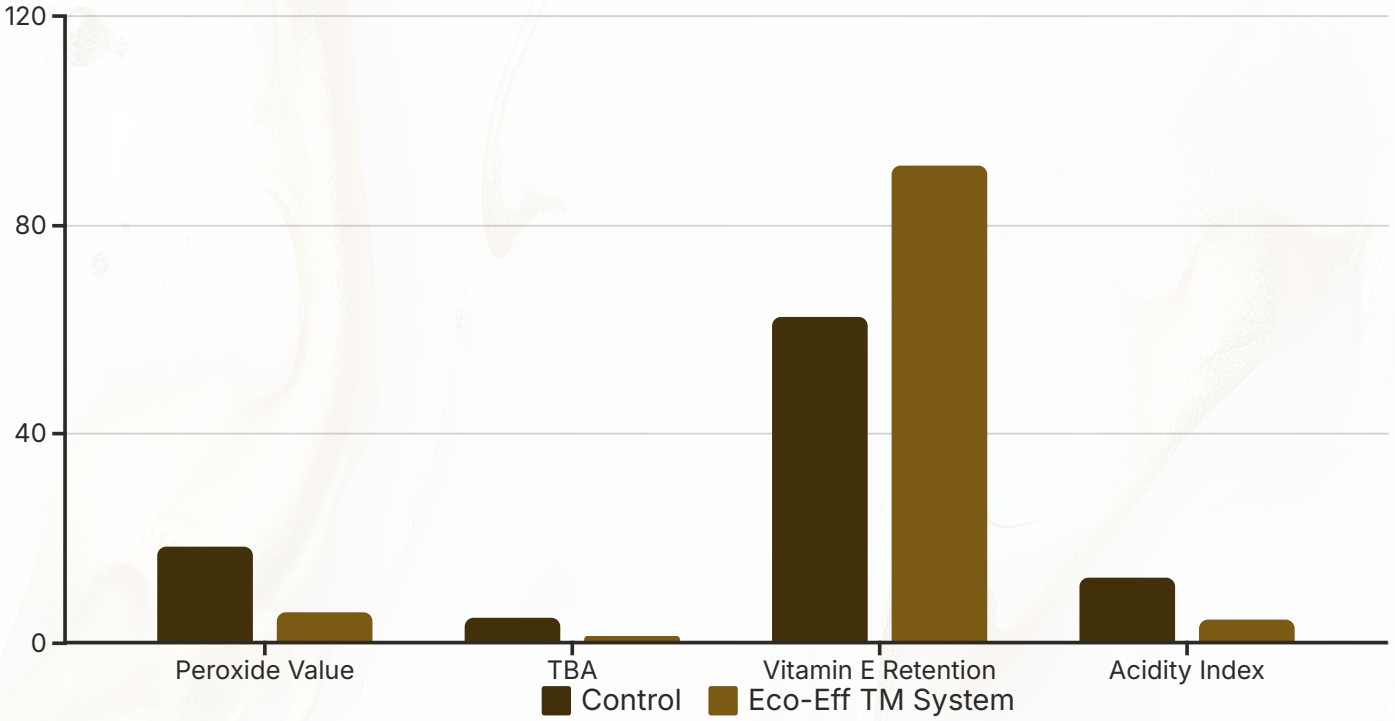
Performance Analysis: The Gold Standard in Stability

After subjecting the system to 90 days of accelerated stress storage conditions (38°C and 85% Relative Humidity), empirical results position Eco-Eff TM as the industry's reference standard:



The charts clearly illustrate the superiority of the Eco-Eff TM System in mitigating oxidation and preserving nutrients.

Parameter	Control (Without Protection)	Eco-Eff TM System
Peroxide Value (meq O_2/kg)	18.5 ± 2.3	**5.8 ± 0.9**
TBA (mg MDA/kg ration)	4.7 ± 0.6	**1.3 ± 0.3**
Vitamin E Retention (%)	62.3%	**91.2%**
Acidity Index (mg KOH/g)	12.3 ± 1.4	**4.5 ± 0.7**

The drastic reduction in malondialdehyde (MDA) formation and the superior preservation of over 90% of Vitamin E ensure that the nutritional investment translates entirely into zootechnical performance.

Beyond Antioxidant: Bioelectric Shield and Process Efficiency

The mineral architecture of Eco-Eff TM provides biophysical functionalities that transcend mere preservation:

Rheological Impact

Acts as a dry lubricant, improving the Hausner flow index by 18%, optimizing precision in automatic dosing

Granulation Efficiency

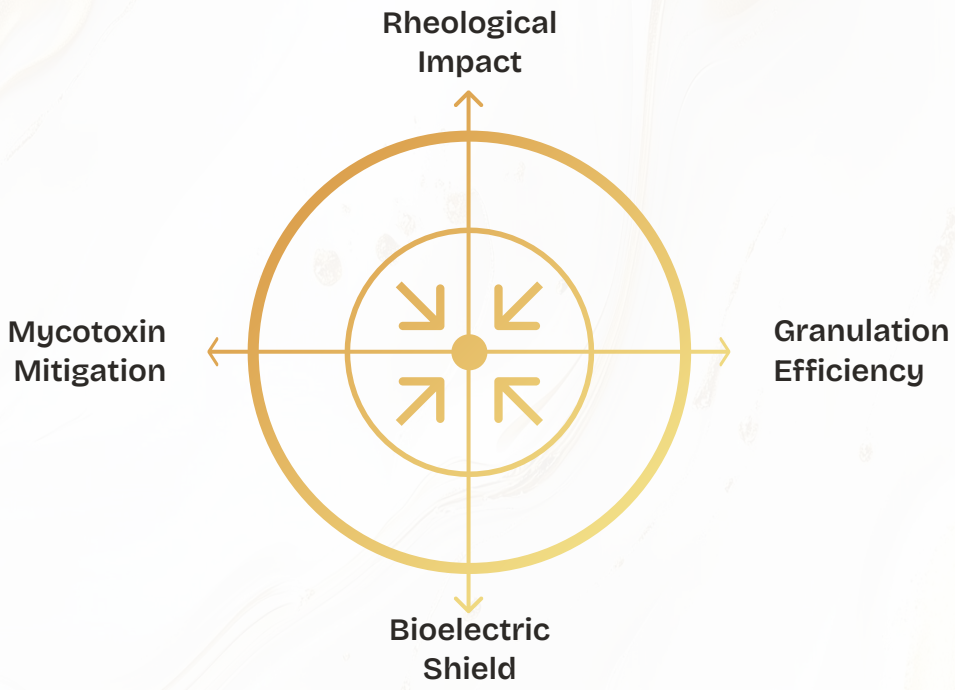
Improves pellet durability and reduces plant energy consumption by 3.8% through rheological optimization

Bioelectric Shield

Alters the cell membrane polarity of pathogens, producing "desiccation cooking" that transforms larvae and eggs into inert remains

Mycotoxin Mitigation

Significant prophylactic reduction in Aflatoxin production through absolute control of interstitial moisture



Strategic Advantage: This physical mechanism prevents the development of genetic resistance, overcoming the limitations of conventional chemical pesticides.

Return on Investment (ROI) and Sustainability in Formulation

The adoption of this mineral technology is a superior asset management decision. While conventional antioxidants offer a linear return, the Eco-Eff TM system guarantees a **conservative ROI of 4.8:1**, which can scale up to **12:1 (>300%)** in high-stress environments and critical formulations.

This return is consolidated through waste reduction (4.2%) and improved animal conversion rate (-2.7%), meeting the demand for pesticide-residue-free production and aligned with global food safety standards.

4.8:1

Conservative ROI

Guaranteed base return

12:1

Optimal ROI

Under critical conditions

4.2%

Waste Reduction

Productive optimization

Differential Advantages: Eco-Eff TM vs. Conventional

Chemical Residues

ABSENT (GRAS) vs. Present/Volatile

Thermal Stability

MAXIMUM (Inorganic) vs. Low/Unstable

Cycle Control

Physical (Eggs/Larvae) vs. None/Poor

Labeling

Clean Label vs. Synthetic Additive


Eco-Eff T™
Eco-Eff T™

Technical Conclusions for Nutritionists

Process biotechnology applied to mineral architecture defines the future of animal nutrition based on three critical premises:

01

Hegemony of the Dual Mechanism

Real innovation lies in the coexistence of a physical barrier through microencapsulation and chemical stabilization through pH control, overcoming the limitations of free radical scavengers.

02

Biophysical Control of the Environment

Grain fusion technology allows for total management of water activity (aw), neutralizing fungal growth and aflatoxin synthesis before their manifestation.

03

Safety and Circularity

The system guarantees production free of synthetic toxicity, allowing integration into Circular Production models (2025-2026) through the safe valorization of by-products with high oxidative risk.

> **Activated mineral architecture is, in short, the definitive tool for the modern nutritionist:** a solution inspired by nature and perfected by cutting-edge biotechnology.

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