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Sectoral Analysis: AMR Drivers in India's Dairy and Seafood Industries

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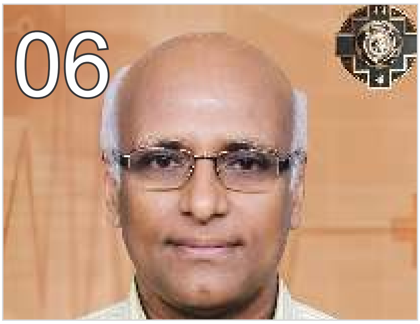

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Erratum: In the previous issue (Volume-12, Issue-7), an image on page 26 was printed incorrectly due to an editorial error. We regret the mistake and apologize to our readers and any individuals or organizations affected.

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Think Grain Think Feed - Volume 12 | Issue 9 | July 2026

Ethno-Veterinary Medicine: India's Path to Responsible Antibiotic Use

Padma Shri Dr N. Punniamurthy
Pioneer of Scientific Ethno-Veterinary Medicine in India

This article is based on a telephonic interaction with the author and has been edited by the Think Grain Think Feed editorial team for clarity and length.

Antimicrobial resistance (AMR) – A challenge to animal health, public health, and sustainable food production. While antibiotics remain indispensable for treating bacterial infections, their indiscriminate use has accelerated the development of resistant pathogens. Addressing this challenge requires more than reducing antibiotic consumption—it calls for rethinking livestock health within a broader ecological framework.

Ethno-Veterinary Medicine (EVM) is often perceived as a collection of herbal remedies. However, its significance extends far beyond traditional medicine. It represents an integrated approach that combines ecological sustainability, preventive healthcare, scientific validation, and responsible antimicrobial stewardship.

"Ethno-Veterinary Medicine does not replace antibiotics; it helps conserve antibiotics. That is the essence of antimicrobial stewardship."

Livestock Health Begins with Ecosystem Health

Modern agriculture, industrialization, and urbanization have transformed food production, but they have also increased environmental pollution and chemical burden on ecosystems. While food safety discussions frequently focus on residue-free milk, meat, and eggs, equal attention must be given to the ecological systems that support livestock production.

Healthy soils are living ecosystems populated by billions of microorganisms that regulate nutrient cycling, plant growth, and overall ecosystem resilience. Today, microbiome science clearly demonstrates that these microbial communities form the foundation of agricultural productivity.

Livestock are equally dependent on these microbial ecosystems. Their digestive tract functions as an extended microbial ecosystem, while their dung and urine eventually return nutrients and microorganisms back to the soil. Therefore, truly sustainable livestock production requires not only residue-free animal products but also biologically healthy manure that enriches rather than degrades soil health.

This ecological perspective places livestock at the centre of sustainable agriculture and reinforces the importance of preventive healthcare approaches.

EVM: More Than Herbal Medicine

EVM should not be viewed simply as the use of medicinal plants. Instead, it forms an important component of circular livestock production.

The National Dairy Development Board (NDDB) has demonstrated that scientifically validated herbal formulations can improve animal health while reducing unnecessary chemical interventions. Importantly, these practices contribute to cleaner dung and urine, which are subsequently recycled into agricultural systems through composting and biogas slurry. As these organic inputs return to the soil, they support healthier microbial populations and strengthen the ecological cycle.

This philosophy aligns closely with India's vision for natural farming, where healthy livestock, healthy soils, and healthy food production become mutually reinforcing.

Conserving Antibiotics for Future Generations

Antibiotics remain essential for treating bacterial infections and saving animal lives. However, decades of unnecessary and indiscriminate use have placed these invaluable medicines at risk.

Every unnecessary antibiotic treatment increases selection pressure for antimicrobial resistance. Meanwhile, the development of new antibiotics has slowed considerably, making conservation of existing antibiotics more critical than ever.

EVM therefore serves as a complementary approach that reduces avoidable antibiotic use in suitable clinical situations while preserving antibiotics for cases where they are genuinely needed.

Science Behind the Traditional Knowledge

The greatest strength of Ethno-Veterinary Medicine programme is that it has moved beyond traditional knowledge into evidence-based veterinary science.

Over the past decade, collaborative work involving NDDB, TANUVAS and TDU has generated one of the world's largest field datasets on Ethno-Veterinary Medicine.

More than 12.5 lakh treatment cases have been digitally recorded and continuously monitored across multiple livestock production systems in India. This extensive database has enabled systematic evaluation of treatment outcomes under field conditions.

Scientific validation has not stopped at field observations. Researchers have applied the same methodologies used in conventional veterinary medicine, including in vitro and in vivo studies, to evaluate EVM formulations. Recent research published in Microbial Pathogenesis (December 2025) further strengthens the scientific foundation of these formulations.

Preliminary findings demonstrate encouraging clinical performance, with an average clinical success rate of approximately 84% under appropriate conditions.

Importantly, the evidence has also been independently evaluated. Studies conducted by the Centre for Science and Environment (Down To Earth) reported findings comparable to NDDB's field data, adding further credibility to the approach.

An independent assessment by the Centre for Science and Environment (CSE) and Down To Earth found that ethnoveterinary medicine achieved an overall clinical success rate of over 80% across nearly 7.8 lakh livestock cases, demonstrating its potential to reduce unnecessary antibiotic use and strengthen India's fight against antimicrobial resistance (AMR).

This growing body of scientific evidence has also contributed to international recognition, with Ethno-Veterinary Medicine being recommended as an important strategy within Global discussions on antimicrobial resistance reduction.

Designing a Truly Pan-Indian Model

Developing healthcare solutions for India's livestock sector requires addressing enormous geographical, climatic, and socio-economic diversity.

Recognising this challenge nearly two decades ago, the objective was never to develop region-specific remedies but to create a scalable national model.

Every EVM formulation was therefore standardized using around 10 commonly available spices and 15 perennial medicinal plants, deliberately avoiding rare, endangered, toxic, or difficult-to-source species. Widely available plants such as neem, tulsi, moringa, along with common household spices, were selected to ensure year-round availability, farmer accessibility, safety, and long-term sustainability.

"Scalability was built into the model from day one. We deliberately avoided rare plants, endangered, toxic, or difficult-to-source plants so that farmers anywhere in India could adopt it."

The standardized EVM model is now being promoted across the country. Technical manuals and educational videos have been translated into 12 Indian languages, significantly improving last-mile adoption among livestock farmers.

This combination of scientific validation, practical simplicity, and nationwide accessibility makes EVM particularly well suited to India's predominantly smallholder livestock systems.

Way Forward

India's livestock sector will remain central to ensuring nutritional security for more than a billion people. Sustainable livestock production therefore demands approaches that simultaneously protect animal health, preserve antibiotic effectiveness, maintain soil health, and strengthen ecological resilience. Ethno-Veterinary Medicine offers precisely such an opportunity—not as a replacement for modern veterinary science, but as a scientifically validated complementary approach that integrates traditional knowledge with contemporary research.

"If India aspires to become a global leader in natural farming, livestock must remain at its centre—and Ethno-Veterinary Medicine should become an integral part of that journey."

The future of livestock production depends not only on healthier animals, but also on healthier ecosystems, healthier soils, and responsible stewardship of antibiotics. By embracing evidence-based Ethno-Veterinary Medicine, India has the opportunity to build a resilient livestock sector that safeguards animal health, protects public health, and conserves one of modern medicine's most valuable resources for generations to come.

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Nutrient variability in Alternate Raw Materials

By **Dr Waghmare Dilip Laxmanrao**, DGM-Nutrition, JAPFA Comfeed

Dr Waghmare Dilip Laxmanrao

Introduction

The search for alternative feed ingredients has become a priority in the animal feed industry to reduce dependence on conventional raw materials and improve sustainability. Rising feed ingredient prices, increasing demand for animal feed, limited availability of land for maize and soybean cultivation, volatile raw material markets, and low poultry meat and egg prices have driven feed manufacturers to explore locally available alternatives.

The successful use of alternative feed ingredients depends on accurate knowledge of their chemical composition and nutritional value. However, limited and inconsistent information often restricts their effective utilization (Bell and Jeffers, 1976). Therefore, thorough evaluation and characterization are essential before incorporating these ingredients into feed formulations.

The growing interest in alternative feed ingredients is driven by several factors:

1. Rapid growth of the commercial poultry sector, with annual growth rates of approximately 8% in layers and 11% in broilers
2. Increasing exports to feed-deficit countries.
3. Market fluctuations caused by stockpiling and supply control.
4. Climate-related production losses due to droughts and floods.
5. Post-harvest losses from poor handling and storage.
6. Rising global demand for vegetable oils.
7. Diversion of maize for biofuel and industrial uses.
8. Environmental concerns surrounding soybean production and increasing competition between feed and food sectors for agricultural land.

To address these challenges, research institutions and seed breeding companies are developing improved feed resources through genetic improvement (such as canola and improved rapeseed cultivars), advanced processing technologies, and better storage practices. At the same time, feed additive companies are enhancing nutrient utilization through enzymes, phytogenic compounds, and other additives that improve digestibility and reduce the effects of anti-nutritional factors (ANFs).

Before incorporating alternative feed ingredients into animal diets, several aspects must be evaluated:

1. Presence and type of anti-nutritional factors (ANFs).
2. Physical characteristics.
3. Chemical composition.
4. Sources of variability.

Understanding these factors is essential for the economical and efficient use of alternative feed ingredients.

Ingredient variability is often compared to an iceberg—only a small portion is visible, while the larger, hidden variation can substantially influence feed quality and bird performance. This challenge is particularly evident with co-products, whose nutrient composition and digestibility may vary widely among suppliers and even between production batches.

Such variability can result in inconsistent nutrient supply, reducing nutrient utilization and limiting the birds' genetic performance potential. Consequently, effective monitoring and management of ingredient variability are critical for producing consistent, high-quality feeds and achieving optimal animal performance.

Effect of feed Raw material variability on overall profitability

The profitability of poultry production is strongly influenced by variations in the nutrient and energy content of feed ingredients. Inconsistent raw material quality affects flock performance, uniformity, and the consistency of production results.

Even small variations in metabolizable energy, nutrient concentration, and amino acid digestibility can influence egg production, egg weight, egg mass, feed conversion efficiency, body weight, energy intake, and ultimately farm profitability. Both physical and chemical variability in feed ingredients can therefore have significant economic consequences.

Alternative feed ingredients are particularly susceptible to variability in their physical characteristics and chemical composition. Such variation alters their nutrient contribution to the final diet, increasing the risk that formulated feeds will not meet the birds' nutritional requirements and reducing production performance.

When the nutrient composition of a raw material is uncertain and cannot be measured before use, nutritionists must assign estimated nutrient values during formulation. If the actual nutrient content is lower than the assigned value, birds may receive inadequate nutrients, leading to poorer health, reduced growth, lower productivity, and economic losses. In most cases, these losses exceed the cost of incorporating an appropriate safety margin into the formulation. Consequently, assigning slightly conservative nutrient values is a practical strategy to minimize formulation risk.

Conversely, if the actual nutrient content exceeds the assigned value, nutrients are oversupplied. For example, when the actual lysine content of a feed ingredient is higher than the value used in formulation, birds consume lysine beyond their requirement. Since excess lysine provides little additional production benefit, it becomes an inefficient and costly source of energy, reducing feed cost efficiency.

Therefore, understanding and managing the variability of alternative feed ingredients is essential for accurate feed formulation, efficient nutrient utilization, consistent animal performance, and maximum profitability.

1: Rice DDGS (RDDGS)

Distillers Dried Grains with Solubles (DDGS) is a co-product of ethanol production obtained through the dry-milling process. Its use in animal feeds is often limited by considerable variability in nutrient composition among distilleries, primarily due to differences in raw materials and processing methods (Liu, 2009).

Rice DDGS (RDDGS) contains concentrated levels of most nutrients originally present in rice. However, its nutritional composition varies significantly depending on the grain source and manufacturing process.

Color is a useful indicator of DDGS quality. Excessive drying temperatures produce darker-colored DDGS due to heat damage, which reduces nutrient availability and overall nutritional value (Fastinger et al., 2006).

Quality Characteristics of Good RDDGS

- **Color**
  - Good-quality RDDGS should have a light brown color, similar to fresh de-oiled rice bran.
  - Darker-color RDDGS generally indicates excessive heat treatment during ethanol production, which may reduce nutrient availability.
- **Odor**
  - Fresh RDDGS typically have a sweet and mildly fermented aroma.
  - A burnt or smoky odor indicates overheating during processing and is often associated with inferior nutritional quality (Cromwell et al., 1993).
- **Particle Size**
  - RDDGS should have a uniform particle size.
  - Uniform particles improve ingredient mixing, feed manufacturing efficiency, and diet consistency.

Crude Protein and Lysine Variability in Rice DDGS

The Regional Analytical Laboratory of JAPFA Comfeed Pvt. Ltd. analyzed 43 Rice DDGS (RDDGS) samples collected from different regions of India between January and September 2025. The results showed substantial consignment-to-consignment variation in both physical characteristics and

Fig. 1. Factors resposible for Color variability in Rice DDGS samples

Factors influencing nutrient composition of distiller's co-products (adapted from Olentine, 1986)

Raw Materials	Processing Factors
Types of grains	Grind Procedure
Grain variety	Fineness Duration
Grain quality	Cooking
Soil conditions	Amount of water
Fertilizer	Amount of pre-malt
Weather	Temperature and time
Production and harvesting methods	Continuous or batch fermentation Cooling time
Grain formula	
	Conversion
	Type, quantity and quality of malt
	Fungal amylase
	Time and temperature
	Dilution of converted grains
	Volume and gallon per bushel or grain bill
	Quality and quantity of grain products
	Fermentation
	Yeast quality and quantity
	Temperature
	Time
	Cooling
	Agitation
	Acidity and production control
	Distillation
	Type: vacuum or atmospheric, continuous or batch
	Direct or indirect heating
	Change in volume during distillation
	Processing
	Type of screen: stationary, rotating, or vibratory
	Use of centrifuges
	Type of presses
	Evaporators
	Temperature
	Number
	Dryers
	Time
	Temperature
	Type
	Amount of syrup mixed with grain

chemical composition. No two consecutive consignments had identical quality attributes, demonstrating the inconsistency of commercially available RDDGS.

Crude Protein and Lysine

Crude protein (CP), the principal quality criterion for purchasing RDDGS, is generally expected to be around 44%. However, CP content in the analyzed samples ranged from 40% to 48%, with a coefficient of variation (CV) of 4.29%. Lysine, one of the most critical limiting amino acids in poultry nutrition, showed even greater variability, ranging from 1.27% to 1.77% (CV 7.71%). Such differences can significantly influence feed formulation accuracy and animal performance. Whether diets are formulated using crude

Fig. 2. Color variability in Rice DDGS samples

protein specifications or the Ideal Protein Concept, where precise amino acid balance is essential for optimum growth and efficiency.

These findings highlight the importance of routine nutrient analysis and continuous quality monitoring of RDDGS before its inclusion in feed formulations.

Crude Fat and Crude Fiber

Analysis of 43 Rice DDGS (RDDGS) samples showed considerable variability in both crude fat and crude fiber content. Crude fat ranged from 1.45% to 5.54%, with a coefficient of variation (CV) of 44.19%, indicating marked inconsistency among consignments. Crude fiber ranged from 2.11% to 5.32%, with a CV of 19.93%.

Such variability can significantly influence feed quality and animal performance. Differences in crude fat affect dietary energy density, pellet quality, and feed handling characteristics, whereas variation in crude fiber influences nutrient digestibility, gut function, and overall feed utilization. Consequently, inconsistent fat and fiber levels can lead to variations in feed efficiency and production performance if not properly accounted for during feed formulation.

2. Rapeseed Meal (RSM):

The nutritional value of alternative feed ingredients depends on accurate characterization of their chemical composition. In the case of rapeseed meal (RSM), despite numerous studies on well-defined experimental samples, published information on the composition and variability of commercially available RSM remains limited (Bell & Jeffers, 1976).

To assess the quality of RSM marketed in the Indian feed industry, 64 commercial samples were collected from different regions of India between January 1 and July 30, 2025. Considerable variation was observed among consignments in both physical appearance and chemical composition.

All samples were analyzed for proximate composition, including moisture, crude protein (CP), ether extract (fat), crude fiber (CF), and ash.

Crude Protein and Lysine

Crude protein remains the primary parameter used for pricing and feed formulation of RSM. Commercial RSM is generally assumed to contain approximately 37% CP. However, the analyzed samples ranged from 35.43% to 39.30% CP, with a coefficient of variation (CV) of 2.49%, indicating moderate variability.

Greater variation was observed for lysine, the first limiting amino acid in poultry diets. Lysine content ranged from

Fig. 3. Chemical composition of Rice DDGS samples showing variability in crude protein and lysine (%)

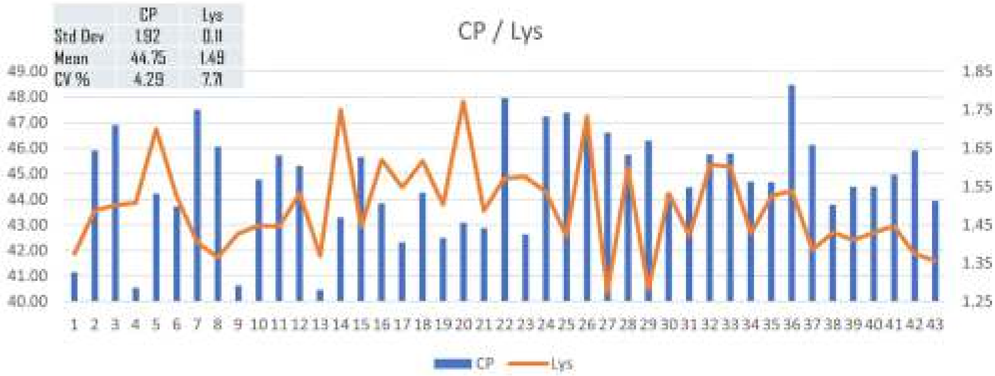


Fig. 4. Chemical composition of Rice DDGS samples showing variability in crude fat and crude fiber (%)

Table 1. Chemical analysis of Rice DDGS samples

Sample No.	CP	Lys	Fat	Fiber	Sample No.	CP	Lys	Fat	Fiber
1	41.16	1.38	5.54	3.00	23	42.63	1.58	1.79	3.68
2	45.90	1.49	5.24	3.94	24	47.23	1.54	4.40	4.00
3	46.91	1.50	2.28	3.85	25	47.38	1.42	3.92	3.88
4	40.54	1.51	6.63	3.85	26	46.99	1.73	3.92	3.85
5	44.23	1.70	4.63	3.89	27	46.60	1.27	1.85	3.87
6	43.73	1.53	3.09	3.95	28	45.73	1.60	1.58	3.95
7	47.51	1.41	3.11	2.27	29	46.29	1.28	1.96	4.00
8	46.05	1.37	3.24	2.24	30	44.24	1.53	1.62	3.95
9	40.62	1.43	2.29	3.95	31	44.48	1.42	3.23	2.99
10	44.78	1.45	1.99	3.06	32	45.75	1.61	2.25	3.92
11	45.72	1.45	2.29	3.95	33	45.79	1.60	2.89	3.92
12	45.31	1.53	2.29	3.95	34	44.70	1.43	2.33	4.92
13	40.46	1.37	2.25	2.87	35	44.68	1.53	2.48	4.73
14	43.30	1.75	2.25	3.11	36	48.48	1.54	1.48	4.71
15	45.65	1.45	2.94	3.96	37	46.11	1.39	1.52	5.32
16	43.85	1.62	3.09	3.90	38	43.80	1.43	2.08	3.98
17	42.32	1.55	3.10	2.78	39	44.50	1.41	2.45	2.36
18	44.27	1.62	3.16	2.89	40	44.52	1.43	2.69	4.93
19	42.50	1.50	1.45	3.58	41	44.97	1.45	1.59	4.24
20	43.10	1.77	1.85	3.10	42	45.90	1.37	1.65	2.11
21	42.87	1.49	1.45	3.95	43	43.95	1.36	1.65	3.92
22	47.96	1.57	1.85	2.93					

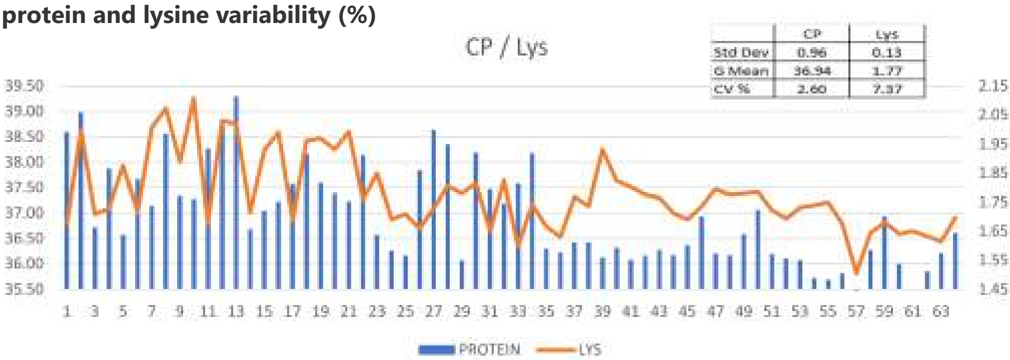
Fig. 5. Color variability in RSM samples

1.51% to 2.11%, with a CV of 7.37%, demonstrating substantially higher variability than crude protein.
These findings indicate that batches with similar crude protein levels can differ considerably in digestible amino acid supply. Formulating diets based solely on crude protein may therefore result in lysine deficiencies or imbalanced amino acid profiles, reducing feed efficiency. Such inconsistencies can lead to poorer feed conversion ratio (FCR), slower growth, greater flock variability, or increased reliance on synthetic amino acids. These results emphasize the importance of routine amino acid analysis rather than relying on average book values in precision feed formulation.

Crude Fat and Crude Fiber

Analysis of the 64 RSM samples also revealed considerable variation in crude fat and crude fiber content. Crude fat ranged from 0.52% to 1.51%, with a CV of 14.20%, indicating high variability among consignments. Crude fiber ranged from 7.01% to 11.57%, with a CV of 8.80%.
Variability in crude fat affects the energy contribution of RSM and may influence pellet quality and feed handling characteristics. Differences in crude fiber content can alter nutrient digestibility, feed intake, gut health, and nutrient utilization, ultimately affecting bird performance. These findings highlight the need for regular quality monitoring of commercial RSM to ensure consistent feed formulation and predictable production outcomes.

Fig. 6. Chemical composition of RSM samples showing crude protein and lysine variability (%)



Summary

Analysis of 43 DDGS and 64 RSM samples collected from the East, West, and North regions between January 1 and September 30, 2025, revealed moderate to high variability in key nutritional parameters, including crude protein (CP), lysine, crude fat, and crude fiber.
Comparison of the observed analytical values with standard nutrient specifications reported for rice DDGS and RSM showed considerable variation across nutrients. These differences indicate that feed formulations based solely on standard reference values may lead to inaccurate nutrient estimations and a mismatch between expected and actual animal performance.
Therefore, regular laboratory evaluation of each consignment is essential when using alternative feed ingredients. Nutritionists should consider actual analytical data rather than relying exclusively on published nutrient tables to achieve more accurate and consistent feed formulation.

Acknowledgment

I sincerely acknowledge the support of the Regional Laboratory In-Charge, Japfa Comfeed India Pvt. Ltd., for providing detailed analytical data for each sample and for the valuable guidance and assistance throughout this study.
I also extend my gratitude to the management of Japfa Comfeed India Pvt. Ltd. for providing the opportunity to conduct this work and granting permission to publish the findings. Their encouragement, cooperation, and support were invaluable to the successful completion of this study.

References are available upon request.

Fig. 7. Chemical analysis of RSM samples showing variability in crude fat and crude fiber (%)

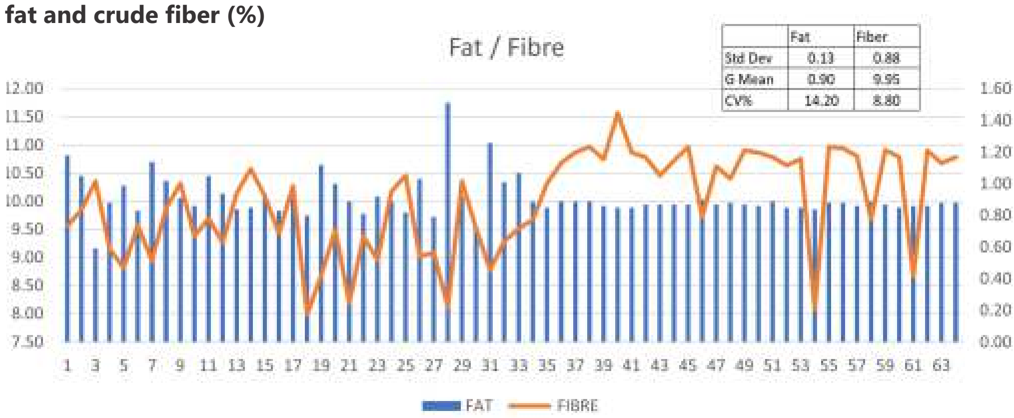


Table 2. Chemical analysis of RSM

Sample No.	CP	Lys	Sample No.	CP	Lys	Sample No.	Fat	Fiber	Sample No.	Fat	Fiber
1	38.60	1.68	33	37.58	1.60	1	1.18	9.56	33	1.07	9.52
2	38.98	2.00	34	38.18	1.74	2	1.05	9.85	34	0.89	9.67
3	36.72	1.71	35	36.30	1.67	3	0.59	10.36	35	0.85	10.32
4	37.88	1.73	36	36.23	1.63	4	0.88	9.16	36	0.89	10.69
5	36.57	1.88	37	36.42	1.77	5	0.99	8.82	37	0.89	10.88
6	37.67	1.72	38	36.42	1.74	6	0.83	9.58	38	0.89	10.97
7	37.15	2.01	39	36.12	1.93	7	1.14	8.95	39	0.86	10.75
8	38.57	2.07	40	36.32	1.82	8	1.02	9.88	40	0.85	11.57
9	37.34	1.89	41	36.08	1.80	9	0.91	10.32	41	0.85	10.87
10	37.28	2.11	42	36.16	1.78	10	0.86	9.38	42	0.87	10.78
11	38.27	1.68	43	36.28	1.77	11	1.05	9.70	43	0.87	10.46
12	38.73	2.03	44	36.17	1.71	12	0.94	9.26	44	0.87	10.73
13	39.30	2.02	45	36.37	1.69	13	0.84	10.15	45	0.87	10.97
14	36.69	1.72	46	36.93	1.74	14	0.85	10.58	46	0.90	9.73
15	37.05	1.93	47	36.20	1.80	15	0.94	10.09	47	0.87	10.63
16	37.23	1.99	48	36.17	1.78	16	0.83	9.43	48	0.88	10.41
17	37.57	1.69	49	36.59	1.78	17	0.98	10.27	49	0.87	10.91
18	38.17	1.96	50	37.06	1.79	18	0.80	7.99	50	0.86	10.87
19	37.60	1.97	51	36.19	1.72	19	1.12	8.68	51	0.89	10.79
20	37.39	1.93	52	36.10	1.69	20	1.00	9.49	52	0.85	10.64
21	37.24	1.99	53	36.07	1.73	21	0.89	8.19	53	0.85	10.76
22	38.14	1.76	54	35.73	1.74	22	0.81	9.38	54	0.84	8.08
23	36.57	1.85	55	35.69	1.75	23	0.92	8.96	55	0.88	10.97
24	36.26	1.69	56	35.82	1.68	24	0.89	10.18	56	0.88	10.95
25	36.16	1.71	57	35.43	1.51	25	0.82	10.46	57	0.86	10.81
26	37.84	1.66	58	36.27	1.64	26	1.03	9.02	58	0.89	9.68
27	38.64	1.73	59	36.93	1.68	27	0.79	9.09	59	0.87	10.92
28	38.35	1.81	60	36.00	1.64	28	1.51	8.12	60	0.85	10.79
29	36.07	1.78	61	35.51	1.65	29	0.92	10.36	61	0.86	8.67
30	38.19	1.82	62	35.86	1.63	30	0.72	9.52	62	0.86	10.91
31	37.47	1.65	63	36.21	1.62	31	1.26	8.78	63	0.88	10.68
32	37.19	1.83	64	36.61	1.70	32	1.01	9.29	64	0.88	10.79

Sectoral Analysis: AMR Drivers in India's Dairy and Seafood Industries

By **Satish Mohite**, Principal Advisor - Dairy & Food Lab Analytics

Satish Mohite

Antimicrobial Resistance (AMR) is one of India's most pressing public health challenges, demanding coordinated action across human, animal, and environmental health. As the world's largest milk producer and a leading seafood exporter, India has a unique opportunity to strengthen antibiotic stewardship within its food-animal production systems. Responsible antimicrobial use, effective surveillance, and sustainable farming practices are critical to safeguarding public health while limiting the spread of antimicrobial-resistant microorganisms through the food chain and the environment.

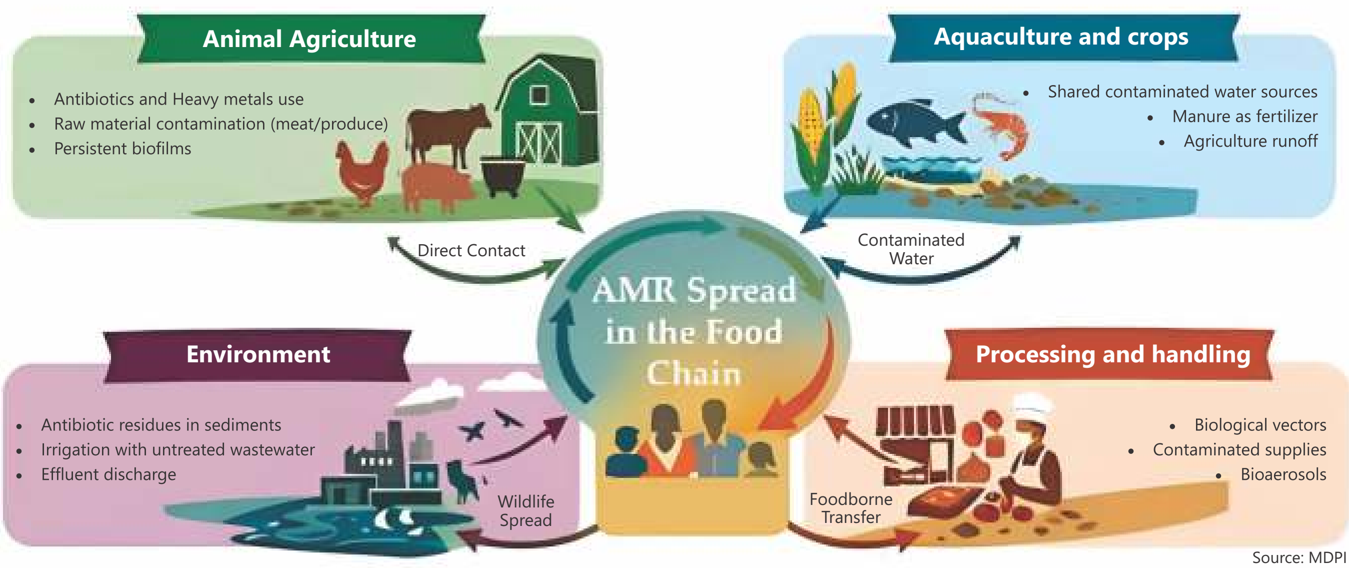
The intensification of livestock and aquaculture production, combined with the inappropriate use of veterinary antimicrobials and inconsistent regulatory oversight, has accelerated the emergence and spread of antimicrobial-resistant bacteria, increasing risks to both animal and human health.

The Dairy Industry: Mastitis and Informal Value Chains

India's dairy sector is highly fragmented, with over 70% of milk produced and marketed through informal value chains. This decentralized system makes regulating antimicrobial use and enforcing antibiotic stewardship particularly challenging.

- **Inappropriate therapeutic use:** Antibiotics such as oxytetracycline, ampicillin, and amoxicillin are commonly used, often without veterinary supervision, to treat mastitis in high-yielding dairy cattle and buffaloes.
- **Poor compliance with withdrawal periods:** Many smallholder farmers do not observe the prescribed withdrawal period after antibiotic treatment, allowing antibiotic residues to enter the commercial milk supply.
- **Prevalence of resistant pathogens:** Surveillance studies from West Bengal and Haryana have reported antimicrobial-resistant bacteria in raw milk. In West Bengal, 12.1% (22/182) of raw milk samples contained *Escherichia coli,* with 54.5% (12/22) identified as Extended-Spectrum β-lactamase (ESBL)-producing isolates. A Haryana study found ESBL-producing *E. coli* in 30.8% (74/240) of isolates, while 37.8% of *E. coli* recovered from raw milk exhibited ESBL production. Most isolates showed resistance to tetracyclines and third-generation

Fig. 1. AMR transmission pathways across the food chain



Source: MDPI

cephalosporins, highlighting the growing AMR burden in India's dairy sector.

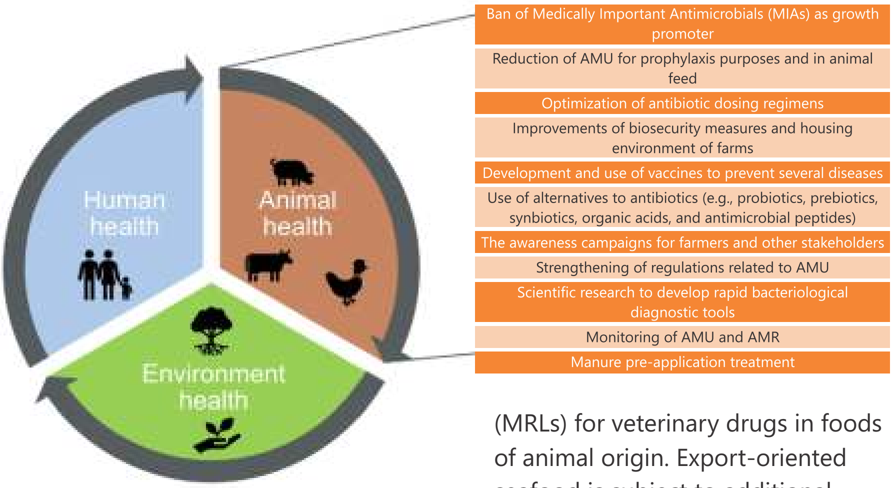
The Seafood and Aquaculture Industry: Environmental Dissemination of AMR

India's brackishwater shrimp and freshwater aquaculture sectors have expanded rapidly to meet domestic and export demand. While intensification has improved productivity, it has also increased the risk of antimicrobial resistance (AMR) through inappropriate antibiotic use and the spread of resistant microorganisms.

- **Environmental dissemination of antibiotics:** Unlike terrestrial livestock systems, a significant proportion of antibiotics used in aquaculture enters surrounding water and sediments through excretion and pond discharge, creating continuous selective pressure for antimicrobial-resistant bacteria.
- **High stocking density and preventive antibiotic use:** Intensive farming systems with high stocking densities are more vulnerable to disease outbreaks. Inadequate biosecurity and limited access to rapid diagnostics often encourage prophylactic use of broad-spectrum antibiotics.
- **Occurrence of resistant pathogens:** Indian studies have identified multidrug-resistant Vibrio spp. (*Vibrio parahaemolyticus*), *Aeromonas spp.*, and members of the *Enterobacteriaceae* family in cultured shrimp, fish, pond water, and sediments.

One Health Implications

Resistance genes generated within



aquaculture systems extend beyond production ponds. Pond effluents, flooding, irrigation canals, and surface runoff facilitate their spread into rivers, agricultural land, and drinking water sources, increasing transmission risks across animals, humans, and the environment. These interconnected pathways reinforce the need for a One Health approach integrating animal health, environmental management, and public health.

Regulatory and Mitigation Frameworks

India has progressively strengthened its AMR response through a One Health framework focused on surveillance, residue monitoring, and sustainable disease management.

- **AMR surveillance:** The Indian Network for Fishery and Animal Antimicrobial Resistance (INFAAR), established by ICAR with technical support from FAO, monitors AMR trends in livestock and aquaculture and provides scientific evidence to support stewardship programmes.
- **Residue monitoring and regulatory standards:** FSSAI regulates Maximum Residue Limits (MRLs) for veterinary drugs in foods of animal origin. Export-oriented seafood is subject to additional residue monitoring and certification through the Export Inspection Council (EIC) and MPEDA to meet importing-country requirements.
- **Promotion of non-antibiotic disease management:** Research institutions, including ICAR–Research institutions, including ICAR–CIBA, are promoting biosecurity, probiotic (CIBA), are promoting biosecurity, probiotics, immunostimulants, improved farm management, and disease surveillance as sustainable alternatives to antibiotics.

Regional and State-Level Variations in AMR

AMR patterns vary across India because of differences in antibiotic use, healthcare infrastructure, agricultural practices, industrial activity, and surveillance capacity.

- **Delhi and Maharashtra – Urban high-resistance clusters:** These regions report a high burden of carbapenem-resistant Enterobacteriaceae (CRE) and other multidrug-resistant pathogens through hospital-based surveillance networks. High population density,

Pathogen	Reported resistance findings in Indian dairy studies
Gram-negative bacteria (*E. coli, Klebsiella spp.*)	ESBL-producing isolates have been reported in raw milk from Haryana, West Bengal, and Gujarat, with resistance commonly associated with third-generation cephalosporins and blaCTX-M genes.
Staphylococcus aureus	MRSA has been detected in bovine milk from several Indian studies, although reported prevalence varies considerably across regions.
Escherichia coli	High resistance to tetracyclines and third-generation cephalosporins has been consistently reported among isolates from raw milk.

extensive tertiary healthcare services, frequent antibiotic use, and healthcare-associated transmission contribute to elevated resistance levels. The globally significant New Delhi metallo-β-lactamase-1 (NDM-1) resistance gene, first identified in New Delhi in 2008, remains closely associated with carbapenem resistance.

- **Andhra Pradesh and Telangana – Aquaculture and pharmaceutical hubs:** Intensive aquaculture, livestock production, and pharmaceutical manufacturing have made these states a focus for One Health surveillance. Environmental studies have detected antimicrobial residues and multidrug-resistant *Escherichia coli* and *Vibrio spp.* in surface waters.
- **Kerala – A model for antimicrobial stewardship:** Kerala became the first Indian state to implement a comprehensive AMR strategy through the Kerala Antimicrobial Resistance Strategic Action Plan (KARSAP) and the Kerala Antimicrobial Resistance Surveillance Network (KARS-Net). Complementary initiatives such as Operation Amrith have strengthened prescription monitoring and restricted inappropriate over-the-counter antibiotic sales.

Decadal Progression of Antimicrobial Resistance (2015–2025)

Surveillance by the ICMR Antimicrobial Resistance Surveillance and Research Network (ICMR-AMRSN) shows a steady rise in resistance among priority bacterial pathogens over the past decade, with declining effectiveness of several first-line and last-resort antibiotics.

Approximate Trend	2015	2020	2025
Methicillin-resistant *Staphylococcus aureus* (MRSA)	~28%	~40%	>43%
Imipenem-resistant (IPM-R) *Klebsiella pneumoniae*	~35%	~55%	>57%
Escherichia coli susceptible to third-generation cephalosporins	~25%	<16%	<12%

Macro Drivers Behind the Rise of Antimicrobial Resistance

The rise of antimicrobial resistance (AMR) in India over the past decade is driven by interconnected demographic, healthcare, and agricultural factors that have accelerated the emergence and spread of resistant pathogens while highlighting the need for stronger antimicrobial stewardship.

- **Rising antibiotic consumption:** India remains one of the world's largest antibiotic consumers. Population growth, improved healthcare access, widespread availability of low-cost generic medicines, and inappropriate use in both human and veterinary sectors have increased antimicrobial consumption, often outpacing stewardship and prescription monitoring.
- **Burden of neonatal sepsis:** AMR has complicated the treatment of neonatal

Table 1. Critical Pathogen Data Analysis

Pathogen & Clinical Threat	Resistance Profile (2015-2016)	Current Resistance Profile (2025-2026 Data)	Major Clinical Impact
Klebsiella pneumoniae (Pneumonia, Neonatal Sepsis)	Approximately 35% resistant to carbapenems (last-resort antibiotics such as imipenem/meropenem)	More than 57% resistant to carbapenems, with declining susceptibility to multiple therapeutic options	Intensive Care Units (ICUs), newborn nurseries
Acinetobacter baumannii (Healthcare-associated infections)	Already exhibited high resistance, while retaining limited susceptibility to reserve antibiotics	Approximately 87.5% resistant to carbapenems in many tertiary-care hospitals, leaving very limited treatment options, including colistin-based therapies	Ventilator-associated infections, trauma care, and critical care units
Staphylococcus aureus (Skin, bloodstream infections)	MRSA prevalence of approximately 28%	MRSA prevalence exceeds 40% in many surveillance reports	Surgical site infections, bloodstream infections, and community-associated skin infections
Escherichia coli (Urinary tract infections, sepsis, diarrhoeal disease)	High resistance to third-generation cephalosporins (~75% resistant)	Resistance to third-generation cephalosporins exceeds 85%, while susceptibility to fluoroquinolones has declined to below 30% in several surveillance centres	Community- and hospital-acquired urinary tract infections, sepsis, and gastrointestinal infections

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sepsis, a leading cause of infant mortality. Multidrug-resistant infections are estimated to contribute to tens of thousands of neonatal deaths annually, underscoring the need for improved infection prevention, diagnostics, and antimicrobial stewardship.

- **Expansion of surveillance:** The apparent rise in resistance also reflects improved detection and surveillance rather than only an epidemiological increase. Expansion of the ICMR Antimicrobial Resistance Surveillance and Research Network (AMRSN) and surveillance programmes coordinated by the National Centre for Disease Control (NCDC) has strengthened national monitoring and evidence-based policymaking.

Transition Toward Antibiotic Stewardship

Recognizing the public health and economic impact of AMR, India's dairy and aquaculture sectors are increasingly adopting science-based strategies that emphasize disease prevention, surveillance, responsible antimicrobial use, and biological alternatives. Key institutions including NDDB, MPEDA, and ICAR are leading these efforts.

Dairy Sector Initiatives

Given the fragmented nature of India's dairy industry, dominated by smallholder farmers, mitigation strategies primarily focus on providing practical, cost-effective alternatives that reduce dependence on antibiotics.

1. Ethnoveterinary Medicine (EVM)

Led by NDDB in collaboration with the University of Trans-Disciplinary Health Sciences and Technology (TDU), the most successful intervention against antibiotic misuse in Indian dairying is the institutional integration of the EVM. The programme promotes scientifically validated herbal formulations for common livestock diseases.

- **Mastitis management:** Herbal formulations containing Aloe vera, turmeric (*Curcuma longa*), and calcium hydroxide (lime) have shown promise as alternatives or supportive therapies, reducing routine antibiotic use.
- **Field impact:** NDDB reports implementation in over one million documented cases, achieving approximately 80% recovery and an 87.9% reduction in antibiotic residues in the commercial milk pool.

2. Mastitis Control Sub-Models (MCSM)

Dairy cooperatives such as Amul and Mother Dairy have adopted preventive mastitis control programmes focusing on:

- Early detection using the California Mastitis Test (CMT) to identify subclinical infections and enable targeted treatment.
- Post-milking teat dipping, which studies indicate can reduce new intramammary infections by 40–50%.

3. Milk Traceability and Quality Assurance

Large cooperatives are increasingly digitizing milk procurement and incorporating rapid antibiotic residue screening at collection centres, enabling segregation of non-compliant milk and improving adherence to withdrawal periods.

Seafood and Aquaculture Sector Initiatives

To meet stringent export requirements from markets such as the European Union, United States, and Japan, India's aquaculture sector has strengthened traceability, residue monitoring, and certification systems through MPEDA and the Coastal Aquaculture Authority (CAA).

1. SHAPHARI Certification Scheme

Developed by MPEDA, SHAPHARI is a web-based traceability and certification programme covering the aquaculture production chain.

- Certified hatcheries follow prescribed biosecurity standards, while post-larvae are screened for prohibited substances, including chloramphenicol and nitrofuran metabolites.
- Shrimp farms supplying export markets undergo Pre-Harvest Testing (PHT), with export approval dependent on compliance with residue limits.

2. Regulation of

Aquaculture Inputs

The CAA regulates aquaculture through farm registration, licensing, and oversight of feed and other production inputs.

- Manufacturers must comply with regulations governing antibiotic-free aquaculture inputs.
- The CAA prohibits the use of 20 antibiotics and pharmacologically active substances, including chloramphenicol and nitrofurans, in export-oriented aquaculture. Detection may result in shipment rejection and regulatory action.

3. Biological Alternatives

Research institutions such as ICAR-CIBA are promoting alternatives to antibiotics, including:

- **Organic acid blends** to improve gut health, feed efficiency, and suppress pathogenic *Vibrio spp.*
- **Probiotics** to enhance pond microbial balance and water quality, while bacteriophage-based therapies continue to show potential against *Vibrio* infections.

Cross-Sectoral Monitoring: National Residue Control Programme (NRCP)

Monitoring antibiotic residues through Maximum Residue Limits (MRLs) is a key element linking India's dairy and aquaculture sectors. For export products, the National Residue Control Plan (NRCP), implemented by the Export Inspection Council (EIC), ensures compliance with importing-country requirements. Within the domestic market, FSSAI establishes residue standards and conducts surveillance through state food safety authorities.

Export systems rely on risk-based sampling and laboratory testing before shipment, while domestic monitoring focuses on processing facilities and retail markets. However, surveillance intensity continues to vary across regions because of differences in infrastructure and enforcement capacity.

Regulatory Differences Between Export and Domestic Supply Chains

India's export-oriented and domestic animal food supply chains operate under markedly different regulatory frameworks. Export markets are subject to stringent residue monitoring to meet international standards, whereas domestic surveillance is constrained by fragmented production systems, limited laboratory capacity, and resource limitations.

1. Limited Economic Incentives

Economic considerations strongly influence compliance with antimicrobial stewardship.

- **Limited consumer premium:** Dairy and fish products in domestic markets are largely sold as commodities, providing little financial incentive for farmers to invest in enhanced biosecurity, probiotics, or compliance with antibiotic withdrawal periods.
- **Cost of withdrawal periods:** Export-oriented producers face significant financial risks—including shipment rejection, loss of market access, and reputational damage—if prohibited residues are detected, creating strong incentives for compliance. In contrast, smallholders supplying domestic markets often receive no premium for residue-compliant products, while observing withdrawal periods results in immediate income loss.

2. Fragmented Production and Marketing Systems

India's decentralized livestock and aquaculture sectors make residue monitoring far more challenging than in integrated export supply chains.

- **Dairy:** More than 70% of milk is marketed through informal channels such as direct farm sales, local vendors, and small processors. Limited traceability, pooled milk collection, and inconsistent residue screening increase the risk of antibiotic residues entering the milk supply if withdrawal periods are followed.
- **Aquaculture:** Export-oriented shrimp farming operates under structured certification and residue monitoring programmes coordinated by MPEDA and CAA. Freshwater aquaculture serving domestic markets consists largely of small and medium-scale producers, resulting in less consistent implementation of traceability and residue monitoring.

3. Differences in Regulatory Capacity

Regulatory responsibilities also differ between export and domestic markets.

- **Export certification** is coordinated by the Export Inspection Council (EIC), with support from MPEDA, and requires rigorous laboratory testing to satisfy importing-country regulations.
- **Domestic food safety** is overseen by FSSAI and state Food Safety Officers. Although residue surveillance programmes exist, nationwide monitoring is limited by laboratory infrastructure, workforce constraints, and the large number of dispersed production and retail sites. Consequently, domestic inspections often prioritize broader food safety concerns—such as adulteration, hygiene, contaminants, and microbiological hazards—over routine antibiotic residue testing.

4. Veterinary Drug Access and Diagnostic Limitations

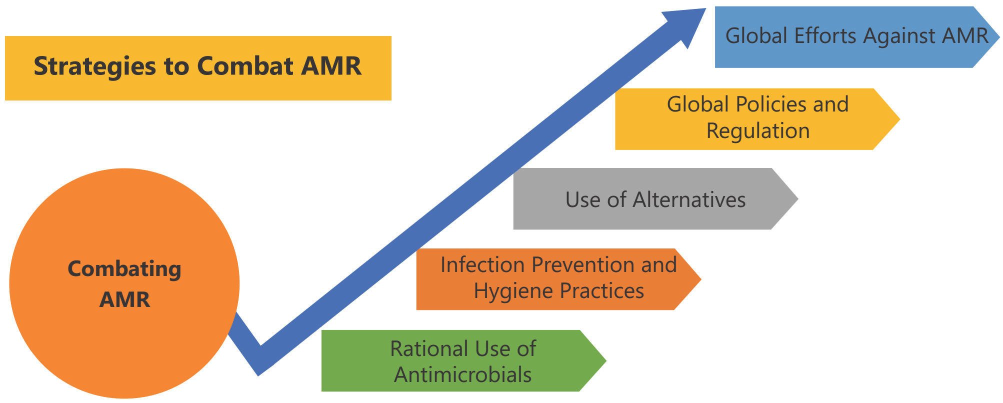
Limited access to veterinary services and diagnostics continues to encourage inappropriate antibiotic use.

- **Variable enforcement:** Although veterinary antibiotics are regulated, enforcement varies across regions, allowing farmers in some areas to obtain antimicrobials without adequate veterinary supervision.
- **Empirical treatment:** Limited availability of rapid, affordable diagnostic tests often leads farmers to use antibiotics without confirming whether infections are bacterial, viral, or parasitic.

Strengthening veterinary extension services, expanding diagnostic capacity, and improving farmer awareness are essential to responsible antimicrobial stewardship.

Conclusion

Expanding antimicrobial stewardship in India's domestic food production systems requires stronger regulatory oversight alongside better economic incentives, wider access to diagnostics and veterinary services, improved farmer education, and greater consumer awareness. As demand grows for residue-compliant and responsibly produced dairy and seafood products, producers will have stronger incentives to adopt practices that reduce unnecessary antibiotic use while maintaining productivity, food safety, and market competitiveness.



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Up to 70% Reduction in Antibiotic Use: Inside NDDB's Dairy AMR Strategy

As antimicrobial resistance (AMR) emerges as one of the most pressing challenges to animal and public health, India's dairy sector is increasingly adopting preventive, science-based approaches to ensure responsible antibiotic use. The National Dairy Development Board (NDDB) has been at the forefront of this transformation through its One Health framework, promotion of Ethno-Veterinary Medicine (EVM), digital herd health management, and farmer-centric capacity building initiatives.

In this exclusive e-interaction, Dr. Meenesh Shah, Chairman, National Dairy Development Board (NDDB), shares insights into India's progress in antimicrobial stewardship, the measurable impact of NDDB's initiatives on reducing antibiotic use, the growing role of EVM, and the roadmap for building a healthier, more sustainable dairy sector.

Dr Meenesh Shah
Chairman, NDDB

How serious is antimicrobial resistance (AMR) in India's dairy sector today? How has antibiotic usage changed over the past decade?

AMR is one of the most significant threats to animal health, public health, and food security. In India's dairy sector, where millions of smallholder farmers depend on livestock, preserving the effectiveness of antibiotics is essential.

Antibiotics remain indispensable for treating bacterial infections. However, their indiscriminate or preventive use has contributed to the emergence of resistant pathogens.

Consequently, dairy health management is increasingly shifting from treatment to prevention through better nutrition, vaccination, biosecurity, hygiene, early diagnosis, and scientifically validated alternatives such as Ethno-Veterinary Medicine (EVM).

Today, antibiotics are viewed not simply as therapeutic tools but as valuable resources that should be used judiciously under veterinary supervision.

In some milk unions where the project has been implemented since 2017–18 and, EVM formulations have been propagated extensively, a reduction of up to around 70% in antibiotic procurement has been observed.

Could you elaborate on NDDB's overall strategy for reducing antimicrobial use and promoting responsible antibiotic stewardship in dairy systems? How many milk unions, dairy cooperatives, and farmers are currently covered?

NDDB follows a One Health approach that integrates animal health, human health, and environmental sustainability. Its strategy focuses on:

The objective is not to eliminate antibiotics but to ensure they are used only when necessary and under veterinary guidance.

This initiative was launched as a pilot in one milk union during 2015-16. Since then, it has expanded significantly and is currently being implemented across 12 milk unions (MUs) and producer companies (PCs) in eight states, covering approximately 1200 villages.

NDDB has been at the forefront of promoting Ethno-Veterinary Medicine (EVM). How does EVM contribute to reducing antibiotic dependence while maintaining animal health and productivity? How many EVM formulations have been scientifically validated and officially recommended?

EVM combines traditional livestock knowledge with scientific validation. NDDB has standardized several formulations for conditions such as mastitis, diarrhoea, indigestion, fever, and reproductive disorders.

These remedies are prepared using locally available medicinal plants and natural ingredients, making them affordable, accessible, and environmentally sustainable. EVM is particularly useful for early-stage and non-specific conditions, helping reduce unnecessary antibiotic use while encouraging timely veterinary consultation whenever required. Rather than replacing modern veterinary medicine, EVM complements it as part of an integrated animal health strategy.

Empirical data from more than 13 lakh cases (which includes over 1 lakh individual animal records) treated by EVM for 30 common ailments in bovines have recorded an overall efficacy of more than 80%. The details of these formulations are freely available on the NDDB Dairy Knowledge Portal and YouTube in 12 vernacular languages including English.

To strengthen the scientific evidence base, NDDB has collaborated with institutions such as St. Thomas College, Palai (Kerala) and the Indian Institute of Science (IISc), Bengaluru, to scientifically validate the ethnoveterinary formulations for the management of mastitis and fever to decipher its molecular mechanisms. The findings on the mastitis formulation have already been published in a peer-reviewed journal, with additional publications in progress. In addition, institutions such as the University of Trans-Disciplinary Health Sciences and Technology (TDU), Bengaluru, and the Tamil Nadu Veterinary and Animal Sciences University (TANUVAS) have also conducted scientific studies on these formulations.

What measurable impact has EVM had on antibiotic consumption, treatment costs, and AMR reduction in milk unions? Could you also shed light on the economics, adoption levels, and efficacy of EVM-based interventions? Has milk yield or animal productivity improved following EVM adoption? If so, could you kindly share the supporting data or figures?

Field implementation of EVM across participating milk unions and producer companies has delivered encouraging results in reducing antibiotic use, lowering treatment costs, and improving animal productivity.

Reduced antibiotic use lowers the selection pressure that drives antimicrobial resistance while also reducing treatment costs. Although the direct impact on AMR requires long-term surveillance, these interventions contribute significantly to antimicrobial stewardship by minimizing unnecessary antibiotic use. NDDB continues to generate scientific evidence to further strengthen the evidence base for EVM.

The impact has also been reflected in animal productivity. In 18,078 individually recorded mastitis cases across participating milk unions and producer companies, animals treated successfully with EVM showed an average increase of 1.27 litres of milk per animal per day following recovery. These data were recorded by project coordinators through NDDB's online project monitoring portal, providing valuable field evidence of the productivity benefits associated with EVM adoption.

Subclinical mastitis affects an estimated 12–70% of lactating cows, making it one of the largest contributors to antibiotic use in dairy animals. What key trends have emerged from NDDB's monitoring of mastitis-causing pathogens and antimicrobial resistance patterns? Additionally, what lessons have been learned from NDDB's mastitis control programmes?

Mastitis remains one of the most economically important diseases in dairy animals and a major driver of antibiotic use. NDDB's surveillance shows that environmental and opportunistic Gram-positive bacteria—particularly non-aureus staphylococci, streptococci, and enterococci—are the predominant pathogens. Staphylococcus aureus, Streptococcus agalactiae, and Escherichia coli have also been isolated, with S. aureus occurring more frequently than E. coli, although environmental pathogens continue to dominate.

AMR surveillance indicates resistance to commonly used antibiotics, including ampicillin and amoxicillin, highlighting the need for a "test-and-treat" approach rather than indiscriminate antibiotic use. At the same time, many isolates remain susceptible to several therapeutic options.

Our mastitis control programmes have shown that prevention—through good milking hygiene, clean housing, dry cow management, proper nutrition, and regular screening—is more effective and economical than treatment. Equally important are farmer awareness, capacity building, and preventive healthcare. NDDB has also demonstrated that Ethno-Veterinary Medicine (EVM) can serve as an effective first-line intervention in many cases, helping reduce unnecessary antibiotic use.

Could you compare the economics of Ethno-Veterinary Medicine (EVM) with conventional antibiotic-based treatment? How do the two approaches differ in terms of treatment costs, recovery time, milk production losses, and overall cost-effectiveness for dairy farmers?

EVM offers an economically viable alternative to conventional antibiotic therapy for many common livestock ailments, particularly when used for appropriate indications and supported by good management practices.

Besides reducing treatment costs, EVM minimizes production losses and supports sustainable dairy farming by reducing reliance on antibiotics.

Compared with conventional antibiotic-based treatment, EVM offers several advantages:

1. Easy to prepare: EVM formulations are prepared using ingredients that are commonly available at the household level, providing farmers with an immediate treatment option, particularly in remote areas with limited veterinary coverage.
2. No milk withdrawal losses: Unlike antibiotics, validated EVM treatments generally do not require milk withdrawal period, allowing farmers to continue marketing milk without income loss. Although, in clinical mastitis cases, abnormal quality milk needs to be discarded.
3. Comparable recovery in suitable cases: For mastitis and several other common bovine ailments, EVM can achieve recovery rates comparable to conventional treatment when administered appropriately.
4. Reduce milk production losses and improved milk quality: By promoting faster restoration of udder health and enhancing the animal's natural immunity, EVM helps minimize milk production losses. Its judicious use, with antibiotics reserved only when absolutely necessary, also reduces the risk of antibiotic residues in milk, thereby improving milk quality and safety.
5. Greater overall cost-effectiveness: Lower treatment costs, reduced milk wastage, decreased antibiotic use, and improved herd health make EVM a highly cost-effective approach for dairy farmers while supporting antimicrobial stewardship and One Health objectives. For example, Nair et al. (2022) reported that the average treatment cost for mastitis was reduced from INR 3,000 to INR 120 per episode, representing a 96% cost saving. Similarly, treatment costs were reduced by 91.6% for maggot wounds, 68.9% for bloat and indigestion, 86.0% for repeat breeding, 42.9% for cowpox, 48.2% for foot-and-mouth disease, and 66.8% for diarrhoea, demonstrating the substantial economic benefits of validated ethno-veterinary practices over conventional allopathic treatment.

The Dairy Integrated Safety and Health Action (DISHA) Project is a significant initiative under NDDB's One Health framework. What are its key objectives, and how is it expected to strengthen AMR mitigation in the dairy sector? Could you also share the current status, key findings, and learnings from the pilot projects implemented so far? What is the roadmap for scaling the programme nationally?

The Dairy Integrated Safety and Health Action (DISHA) Project is NDDB's flagship One Health initiative for improving food safety, animal health, environmental sustainability, and antimicrobial stewardship.

Pilot projects have demonstrated that integrated interventions—including hygiene, vaccination, biosecurity, farmer awareness, and surveillance—can improve animal health while reducing dependence on antimicrobials.

The learnings are now helping develop scalable models for wider implementation across dairy cooperatives. It would also support the Government of India to take informed policy decisions.

How can digital platforms support AMR mitigation?

Digital technologies are transforming livestock management by making scientific information accessible even to smallholder farmers.

INAPH was developed as a comprehensive digital ecosystem for animal identification, breeding, health management, and productivity enhancement, and its framework now underpins the Government of India's Bharat Pashudhan platform. Through the 1962 Farmer App, farmers can securely access information related to their animals, including health, breeding, and productivity records.

The availability of real-time data supports early disease detection, targeted interventions, efficient health monitoring, informed veterinary decisions, evidence-based treatment, and reduced antibiotic use. Going forward, the integration of artificial intelligence, predictive analytics, and genomic tools will enhance disease forecasting and herd management, enabling more resilient and sustainable dairy systems, particularly for India's millions of smallholder producers.

What policy interventions do you believe are necessary to promote responsible antimicrobial use in livestock production?

Effective AMR mitigation requires coordinated action under the One Health framework.

Dairy cooperatives, producer companies, and private dairy enterprises have an important role to play in accelerating adoption through farmer outreach, awareness programmes, capacity building, and field-level monitoring.

Your message for stakeholders?

India's dairy sector has grown through the efforts of millions of farmers. Ensuring its long-term sustainability requires preserving the effectiveness of antibiotics while strengthening preventive animal healthcare.

Prevention must take precedence over cure, and innovation must go hand in hand with traditional wisdom.

Responsible antimicrobial use is a shared responsibility of farmers, veterinarians, researchers, policymakers, and the dairy industry. By combining One Health principles, digital technologies, preventive healthcare, and scientifically validated traditional practices, India can build a more resilient dairy sector while contributing to the global fight against antimicrobial resistance.

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India's Poultry Sector: Progress and Challenges in Reducing Antimicrobial Use

By **Dr (Capt.) Tanweer Alam,** Director-Strategic Marketing, Nutreco South Asia

Dr (Capt.) Tanweer Alam

Dr (Capt.) Tanweer Alam is Director – Strategic Marketing, Nutreco South Asia, with over 30 years of experience in animal health and nutrition. An ex-Army Captain, he has held leadership roles at Kemin and leading veterinary companies. A veterinarian with an MBA, he is former Vice President of INFAH and an expert in strategic marketing and consumer insights.

Antimicrobial Resistance (AMR) is a major issue, globally as well as in India. Suffice it to say, AMR impacts every animal-protein-producing species.

Let's begin with poultry, as poultry meat constitutes roughly 50% of India's total 11 million tonnes of annual meat production.

Historically, antimicrobials have contributed to fueling intensive commercialization over the last few decades by keeping birds alive and productive in challenging conditions. However, this has also resulted in the rise of drug-resistant "superbugs." This not only makes existing solutions for poultry less effective, but according to some studies, AMR generated within the poultry sector also impacts human health through three distinct pathways: the food chain, direct physical contact, and environmental contamination.

It is easy to identify antibiotics as the culprit. However, the issue is more nuanced. Before the intensive production of poultry started in the 1970s, the per capita consumption of poultry was a meagre 160g per annum. Today, the national average is more than 4 kg. In metros, it is 15 kg, and in states like Telangana, it is 21 kg per capita per annum.

The same story applies to eggs. From a per capita consumption of around 10 eggs per year in the 1970s, we are now at 106 eggs per year. One of the prime reasons was that even as general inflation rose, the real (inflation-adjusted) cost of chicken decreased significantly, making it cheaper than other animal protein sources. Along with many other interventions, the sensible usage of antimicrobials also played an important role.

Prima facie, there is nothing wrong with that.

A similar pattern can be seen in agriculture revolution in terms of the usage of fertilizers and pesticides. In the 1960s, for per tonne of food produced, Indian farmers used about 8 kg of fertilizer, and now it is 160 kg. Total agricultural pesticide consumption in India has increased eightfold since the 1960s. More importantly, unlike the global trend where the usage of weedkillers dominates, insecticides still make up over 50% of all chemical pesticides used in Indian agriculture.

As it is rightly said, two wrongs don't make a right. However, the whole point is about how we are attempting to make it right, rather than foreclosing the topic.

A commitment to the cause will make all the difference.

While the European Union enforces some of the world's strictest and most progressive binding regulatory bans on livestock antibiotic misuse, the continent still grapples with challenges in execution. Even in the EU, whereas northern and western Europe maintain exceptionally low antimicrobial resistance due to aggressive stewardship policies, southern and eastern Europe experience severe resistance challenges due to the porous execution of these policies.

The EU plans to implement its 2026 Import Wall policy under which, starting September 2026, the EU will fully enforce a mandatory rule. Under this policy, any foreign country exporting meat or animal products to the EU must legally prove they have banned growth-promoting antibiotics and the 37 critical antimicrobials reserved strictly for human medicine. Interestingly, even giant exporters like Brazil face immediate deletion from authorized trade lists.

With an estimated 2,000 MT to 3,000 MT of antimicrobial usage in India's livestock sector, we consume roughly 3% of the global livestock antimicrobial use. The Indian government has significantly tightened regulations to phase out non-therapeutic antibiotic use. However, a distinct gap remains between statutory laws and actual ground-level enforcement on local farms. While large integrators are modernizing overall management practices, which adds to performance efficiency, smaller farms face a steep financial barrier to upgrading their infrastructure. Consequently, their reliance on prophylaxis remains inevitable if they are to compete in the market.

Interestingly, solutions are at hand. Substituting traditional prophylactic drugs with natural feed alternatives like phytocomplex-based solutions, organic acids, and probiotics to stabilize gut health can support productivity and growth performance in poultry. Phytocomplex solutions—whole-plant extracts containing hundreds of active, naturally synergistic biomolecules—represent one of the most promising frontiers in combating AMR. Unlike conventional antibiotics that typically act through a single primary mechanism, a phytocomplex acts as a multi-target botanical network. This complex structure makes it exponentially harder for pathogens to evolve resistance.

Driven heavily by stricter global regulations on animal antibiotics and a consumer-led "clean-label" movement, the global market for poultry phytogenics has now grown to approximately USD 2 billion. Poultry has become the single largest consumer of plant-based feed tech, capturing 44% of the global feed phytogenics market, and of that, interestingly, the Asia-Pacific (APAC) region accounts for nearly 41% of the global market.

Quantifying exactly how much prophylactic (preventative) and growth-promoting antibiotic usage has been replaced by phytocomplex solutions is complex. This is because phytogenics are rarely used as direct one-to-one substitutes. Instead, they form part of a broader Antibiotic-Free management matrix alongside vaccines, biosecurity, and organic acids. Globally, animal feed experts estimate that phytocomplex solutions have successfully replaced roughly 20% to 30% of the historical market volume once held by sub-therapeutic and prophylactic Antibiotic Feed Additives.

Commercial feed mills and integrators in India are adopting plant-based solutions at a growth rate of 7% annually to keep up with domestic food safety demands and international export compliance. This contrasts with the year-over-year decline in prophylactic feed antibiotic sales in poultry feed (at least among integrators and corporate players). The future of antibiotic usage in poultry feed in India is moving toward the strict, legally mandated elimination of non-therapeutic antimicrobials, transitioning the industry into an Antibiotic-Free operational era.

To survive the future without the preventative crutch of in-feed antibiotics, the poultry industrial matrix is shifting toward a One-Health biosecurity framework, which is the best way forward to restrict the usage of antibiotics and antimicrobials.

Think Grain Think Feed - Volume 12 | Issue 9 | July 2026

Pond-to-port platform for India's shrimp farmers

India's shrimp aquaculture industry is a global success story, but much of its production still comes from small, fragmented farms that face disease outbreaks, inconsistent pricing, limited access to technology and growing demands from international buyers for traceability.

Bhubaneswar-based Aquapulse is looking to bridge these gaps through a technology-enabled, farmer-centric platform that connects shrimp farmers directly with domestic and global markets. Founded in 2023 by Abhishek Dwivedy and Abhilash Dwivedy, the startup operates an "aquapreneur-led" hub-and-spoke model across Odisha, Andhra Pradesh and West Bengal.

Rather than focusing only on procurement or exports, Aquapulse has built an integrated pond-to-port ecosystem that supports farmers throughout the cultivation cycle. The platform offers water quality monitoring, feed management, disease early-warning systems, harvesting coordination, processing partnerships and export logistics, creating a transparent and traceable supply chain.

The model comes at a time when India's seafood exports continue to grow. The country exported nearly 1.97 million metric tonnes of seafood worth over INR 73,890 crore (about USD 8.46 billion) during FY26, with frozen shrimp accounting for the largest share of export earnings. However, the industry's dependence on smallholder farmers has made standardization, quality assurance and traceability persistent challenges.

Aquapulse aims to address these inefficiencies while improving farmer incomes and making smallholders visible participants in the global seafood value chain. The startup, which operates under Phoenix Marine Exports and Solution Pvt Ltd (PMES), exports shrimp primarily to China, Vietnam and Japan, while also supplying domestic institutional buyers and modern retail channels.

To scale its model, Aquapulse recently raised INR 45 crore in a funding round led by NABVENTURES, the venture capital arm of NABARD. The capital will strengthen farm-level technology and disease management, expand procurement networks across eastern India, and scale processing and export operations. Having raised a total of INR 70 crore over the past two months, the company is also investing in AI-led pre- and post-harvest systems, an in-house processing facility and a transparent pricing platform. Investors believe its technology-led approach addresses long-standing inefficiencies in India's aquaculture sector while creating a scalable business.


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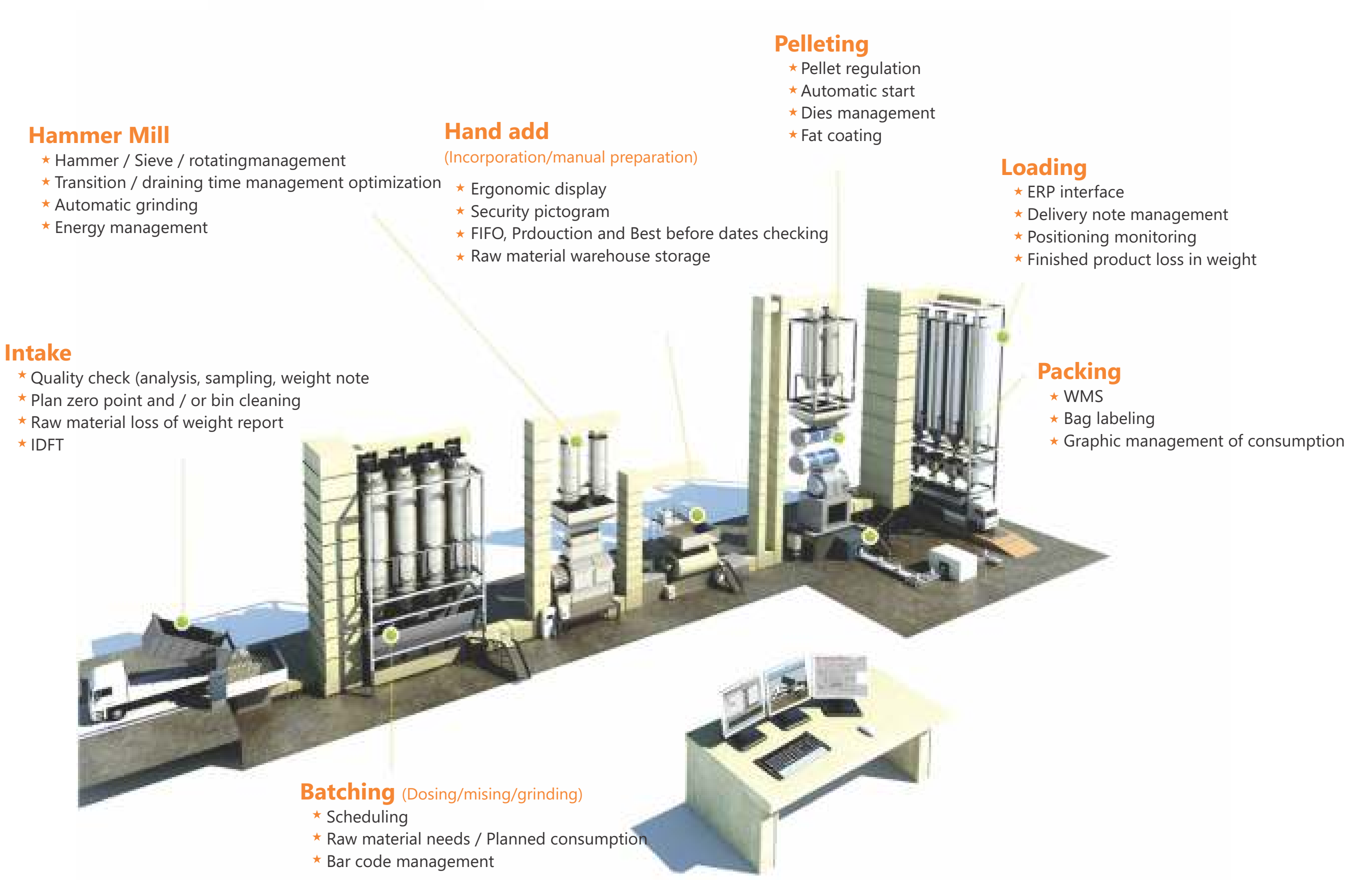

Architecture of India's Digital Feed Mill – Part 2

Analytical Twin: The Bridge Between Digital Automation and the Autonomous Feed Mill

By **V. Sivakumar,** Founder, Feed Tech Engineering, Coimbatore


V. Sivakumar

Modern feed mills have embraced PLCs, SCADA, VFDs, IoT sensors, and Digital Twin technologies to improve throughput, consistency, and operational visibility. While these technologies have transformed automation, they remain largely equipment-centric, focusing on machine control rather than engineering intelligence.

Automation has made feed mills faster. Digitalization has made them more connected. Yet neither can explain why a process deviates, where losses occur, or how to optimize performance.

Current digital systems cannot interpret mass balance deviations, moisture dynamics, thermal behaviour, energy inefficiencies, or quality-related process interactions. Bridging this gap requires a new layer of intelligence—the Feed Mill Analytical Twin.

Automation vs Engineering Intelligence

Automation systems are designed to maintain set points, execute programmed sequences, and ensure safe operation. They excel at controlling machines but cannot understand the engineering relationships between different process stages.

Consider a conventional hammer mill. It can:

- Maintain motor speed
- Regulate feeder rate
- Monitor motor load
- Generate alarms

An Analytical Twin, however, transforms the same machine into an engineering decision system by enabling it to:

- Interpret formulation-specific grinding requirements
- Predict particle size distribution based on ingredient characteristics

- Adjust for moisture variation
- Coordinate grinding with batching, mixing, and pelleting operations
- Calculate grinding energy consumption per tonne and its downstream impact

This marks the transition from control logic to engineering logic.

Why Existing Digital Systems Fall Short

PLCs control equipment. SCADA visualizes data. Digital Twins replicate machine behaviour.

However, none of these systems can answer critical engineering questions such as:

- Where did the unexplained 1–2% material loss occur?
- Which process caused unexpected moisture loss or absorption?
- Why did conditioning temperature fluctuate despite stable steam pressure?
- Why is energy consumption per tonne increasing during peak production?
- Which processing stage affected nutrient uniformity?
- Why did pellet durability decline even though die specifications remained unchanged?

Answering these questions requires engineering models—not automation logic.

A Digital Twin knows the machine. An Analytical Twin understands the manufacturing process.

Engineering Models Inside the Analytical Twin

The Analytical Twin integrates multiple engineering models that continuously analyse and verify process performance across the feed mill, including:

- Mass Balance Model – Detects material losses, spillage, carryover, and yield variations.
- Moisture Balance Model – Tracks moisture movement during grinding, mixing, conditioning, pelleting, and cooling.
- Heat Balance Model – Evaluates thermal efficiency and steam utilization during conditioning, pelleting and cooling.
- Energy Balance Model – Monitors energy consumption (kWh/tonne) and identifies process inefficiencies.
- Grinding Performance Model – Predicts particle size distribution based on ingredient hardness, moisture, screen size and rotor dynamics.
- Mixing Verification Model – Assesses coefficient of variation (CV), ingredient distribution, mixing time and batch uniformity.
- Steam Utilization Model – Evaluates steam-to-moisture conversion efficiency, steam leakage, condensate return and conditioning effectiveness.
- Conditioning Efficiency Model – Correlates dwell time, temperature, moisture, and shear with pellet quality.
- Pellet Quality Prediction Model – Predicts Pellet Durability Index (PDI) using die parameters, formulation characteristics, conditioning profile and mechanical load.
- Cooling Performance Model – Detects over- or under-cooling by monitoring moisture and temperature reduction.
- Nutritional Verification Model – Monitors nutrient retention, thermal degradation, and feed uniformity, supported by farm feedback.
- Feed Traceability Model – Ensures complete traceability from feed mill to farm.

Digital Twin vs. Analytical Twin

Digital Twin	Analytical Twin
Replicates machine behaviour	Replicates process behaviour
Monitors equipment status	Evaluates engineering performance
Predicts mechanical failures	Predicts quality, yield, moisture, and energy performance
Optimizes individual machines	Optimizes interactions across the entire production process
Equipment-centric	Process-centric

Together, these models convert raw sensor data into engineering knowledge, enabling real-time diagnosis, prediction, and decision-making.

Three Levels of Intelligence in Feed Manufacturing

The evolution of feed manufacturing can be viewed in three distinct stages:

Level 1 – Data Intelligence (Digital Twin)

- Data acquisition
- Trend visualization

- Alarm generation
- Equipment monitoring

Level 2 – Engineering Intelligence (Analytical Twin)

- Engineering calculations
- Mass, moisture, heat & energy balance verification
- Root cause diagnosis
- Predictive quality and yield modelling

Level 3 – Autonomous Intelligence (Future Feed Mill)

- AI driven optimization
- Automatic process adjustments within safe operating limits
- Continuous learning from historical data
- Self optimizing process loops

This progression transforms data into information, information into engineering knowledge, and engineering knowledge into intelligent decisions.

From Automation Logic to Engineering Logic

Traditional automation follows a straightforward path:

Sensor → PLC → SCADA → Operator Decision

An Analytical Twin introduces an engineering layer:

Sensor → PLC → Engineering Models → Analytical Twin → AI Engine → Engineering Recommendation → Operator or Autonomous Control

Instead of simply monitoring machines, the system interprets process behaviour, identifies root causes, predicts outcomes, and recommends corrective actions.

Why Engineering Intelligence Matters

Even highly automated mills continue to face:

- Material losses during storage and transfer
- Grinding inefficiencies caused by raw material variability
- Moisture losses during transfer and cooling
- Poor steam utilization due to condensate issues
- Conditioning instability resulting from inconsistent raw materials
- Pellet quality fluctuations despite stable die parameters
- Energy wastage during peak load conditions
- Unexplained yield losses across the production process

Adding more sensors or dashboards will not solve these challenges. What is needed is a deeper understanding of the engineering relationships between process variables.

The Four Evolutions of Feed Manufacturing

The industry has progressed through four distinct phases:

1. Mechanization (1940s): Mechanical equipment replaced manual labour.
2. Automation (1980s): PLCs and VFDs improved consistency, productivity, and safety.
3. Digitalization (2010s): SCADA, IoT, and Digital Twins enabled real-time monitoring and predictive maintenance.
4. Engineering Intelligence (2030s): Analytical Twins transform operational data into engineering decisions and autonomous process optimization.

The Analytical Twin represents the foundation of the next-generation autonomous feed mill.

The Autonomous Feed Mill

Tomorrow's feed mills will no longer be judged by the number of PLCs, sensors, or dashboards they possess. Instead, their success will depend on their ability to answer five critical engineering questions:

- Why did the process deviate?
- Where did the loss occur?
- Which variable caused the quality shift?
- How can the process optimize itself?
- What engineering action is required immediately?

The Analytical Twin provides these answers by transforming machine data into engineering knowledge—and engineering knowledge into intelligent, autonomous action.

Conclusion

Automation made feed mills faster. Digitalization made them connected. Engineering intelligence will make them autonomous.

The Feed Mill Analytical Twin is far more than another digital tool—it is the engineering brain of the future feed mill. By integrating engineering models with real-time process data, it enables consistent product quality, higher yields, improved energy efficiency, and smarter operational decisions. As India's feed industry advances toward autonomous manufacturing, the Analytical Twin will become a critical foundation for sustainable, intelligent, and process-driven feed production.

Author:
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Apo-ester and Canthaxanthin: Properties and Application Strategies in Poultry Pigmentation

By **Mengying Li,** Research and Development Manager, Zhejiang NHU

Mengying Li

Suboptimal pigmentation of egg yolks and broiler carcasses is a common quality concern in commercial poultry production. Natural carotenoid sources such as yellow corn, marigold (Tagetes erecta) meal, and alfalfa meal are susceptible to seasonal variation in pigment content, oxidative degradation during storage, and thermal degradation during pelleting. These factors collectively compromise yolk and carcass pigmentation, frequently resulting in coloration that fails to meet commercial grading standards.

β-Apo-8′-carotenoic acid ethyl ester (apo-ester) and canthaxanthin are synthetic carotenoid feed additives approved for use in many countries, including India. Because of their consistent pigmentation efficacy and superior stability during feed processing, these additives effectively compensate for the limitations of natural carotenoid sources and are therefore extensively used in commercial compound feeds.

Introduction to Apo-ester and Canthaxanthin in Poultry Pigmentation

Apo-ester provides a stable golden-yellow base, contributing to uniform yolk pigmentation and improved carcass surface coloration. Canthaxanthin contributes an orange-red hue, enhancing yolk color saturation, Roche color fan scores, and shank pigmentation. When used together, the two carotenoids act synergistically to produce uniform golden-orange yolks and superior carcass appearance, consistently outperforming single-pigment supplementation in meeting commercial color standards[1].

2. Tissue Deposition and Utilization of Apo-ester and Canthaxanthin in Poultry

As poultry cannot synthesize carotenoids de novo, egg yolk and carcass pigmentation depend entirely on the dietary supply of carotenoids. Once absorbed through the small intestine, carotenoids enter the bloodstream and are deposited in specific tissues, including the ovarian yolk, subcutaneous adipose tissue, and the keratinized layers of the shanks, where they determine the final pigmentation of poultry products[2].

Apo-ester and canthaxanthin possess high lipophilicity and bioavailability, enabling efficient absorption and deposition in lipid-rich tissues, contributing to stable pigmentation. In addition to their pigmentation properties, both carotenoids exhibit antioxidant activity due to their conjugated double-bond structure, helping protect pigments against lipid oxidation and improving color stability during feed processing and storage.

Feeding Trial Results

The feeding trial demonstrated that the combined supplementation of apo-ester and canthaxanthin produced the highest yolk color score (12.46), significantly outperforming both the control and single-carotenoid treatments. While apo-ester and canthaxanthin individually improved yolk pigmentation, their combined use delivered the most consistent and commercially desirable results. Importantly, supplementation had no significant effect on laying rate, egg weight, or feed conversion ratio, confirming that improved pigmentation was achieved without compromising bird performance.

Factors Affecting the Pigmentation Efficacy of Apo-ester and Canthaxanthin

Although apo-ester and canthaxanthin provide consistent pigmentation, their effectiveness is influenced by several nutritional, genetic, processing, and management factors.

1. Basal Pigment Level of Feed Ingredients

Natural carotenoids present in feed ingredients form the basal pigment level of poultry diets. However, pigment concentrations vary with corn maturity, ingredient quality, storage conditions, and dietary formulation. Such variability directly influences carotenoid deposition in tissues, resulting in inconsistent yolk and carcass pigmentation. Consequently, a fixed supplementation rate may not always deliver uniform pigmentation across different feed batches.

2. Genetic Influence on Carotenoid Utilization

Bird genetics play an important role in carotenoid absorption and tissue deposition. Yellow-feathered broilers generally exhibit greater intestinal absorption, transport, and deposition of carotenoids than white-feathered broilers, resulting in superior skin, shank, and carcass pigmentation under similar dietary conditions.

3. Impact of Feed Processing on Pigment Stability

Feed processing conditions, including pelleting temperature, pressure, and prolonged storage, can reduce the stability and biological activity of synthetic carotenoids.

Table 1. Roche Yolk Color Fan Scores of Laying Hens Fed Diets Supplemented with Apo-ester and Canthaxanthin

Dietary Group	Apo-ester (mg/kg)	Canthaxanthin (mg/kg)	Mean Yolk Color Score
Control	0	0	5.36
Trial 1	20	0	11.85
Trial 2	0	2	10.02
Trial 3	20	2	12.46

Note: Data were generated from feeding trials conducted by Zhejiang NHU Co., Ltd. in 2021. Roche yolk color fan scores were recorded after 28 days of continuous feeding in commercial Hy-Line Brown laying hens.

Unprotected apo-ester and canthaxanthin are susceptible to oxidation and thermal degradation, reducing their pigmentation efficacy. To overcome these challenges, microencapsulation technology is widely used to protect carotenoids during feed manufacture and storage while improving their stability and, in many cases, enhancing bioavailability.

4. Husbandry Stress and Pigment Deposition

Environmental and management-related stress can impair lipid metabolism and adipose tissue development, both of which are essential for carotenoid absorption and deposition. Reduced lipid availability limits carotenoid transport in the bloodstream and decreases pigment deposition in target tissues, leading to poorer yolk and carcass pigmentation. These effects result from stress-induced metabolic disturbances rather than any reduction in the intrinsic efficacy of apo-ester or canthaxanthin.

Owing to their high bioavailability and efficient tissue deposition, apo-ester and canthaxanthin can partially offset these stress-related limitations thereby improving carotenoid retention in target tissues and supporting more consistent pigmentation, even under suboptimal production conditions.

Differentiated Supplementation Strategies for Targeted Egg Pigmentation

The complementary pigmentation properties of apo-ester and canthaxanthin enable nutritionists to develop tailored supplementation strategies for different egg market segments. By adjusting their inclusion levels, producers can achieve the desired yolk color while optimizing feed costs and ensuring consistent product quality.

1. Fresh Eggs: Canthaxanthin-Dominant Economical Strategy

For commercial fresh eggs, where moderate yolk color intensity and cost efficiency are the primary objectives, canthaxanthin alone is generally sufficient to meet standard market requirements. A low inclusion of apo-ester may be used to improve color uniformity and fine-tune the golden-yellow hue without significantly increasing pigmentation costs.

2. Premium Branded Eggs: High Apo-ester–Low Canthaxanthin Strategy

Premium egg brands demand superior yolk color intensity, excellent batch-to-batch consistency, and stable pigmentation despite variations in feed ingredients and processing conditions. Fluctuations in natural carotenoid levels can result in inconsistent yolk color. A formulation with a higher level of apo-ester provides a stable golden-yellow base that minimizes this variability, while a lower inclusion of canthaxanthin enhances the orange-red hue and overall color intensity. This combination is particularly suitable for premium egg products that require consistent pigmentation even after thermal processing.

Conclusion

Consistent poultry pigmentation depends on multiple factors, including dietary carotenoid supply, bird genetics, feed processing, and farm management. Apo-ester and canthaxanthin effectively overcome many of the limitations associated with natural carotenoid sources by providing superior bioavailability, processing stability, and complementary pigmentation characteristics.

Whether used individually or in combination, these synthetic carotenoid feed additives enable nutritionists and feed manufacturers to design cost-effective pigmentation programs tailored to specific production objectives. Their strategic application helps deliver uniform yolk and carcass pigmentation, improve product quality, and meet the diverse requirements of commercial and premium poultry markets.

References:

[1]Wang,Zhaoping,Sun, et al. Effect of microencapsulated canthaxanthin and apo-ester on egg yolk color and antioxidant capacity in laying hens[J]. Poultry Science, 2024, 103(12): 104302.

[2]H. Hencken. Chemical and physiological behavior of feed carotenoids and their effects on pigmentation.[J]. Poultry Science, 1992, 71 4.


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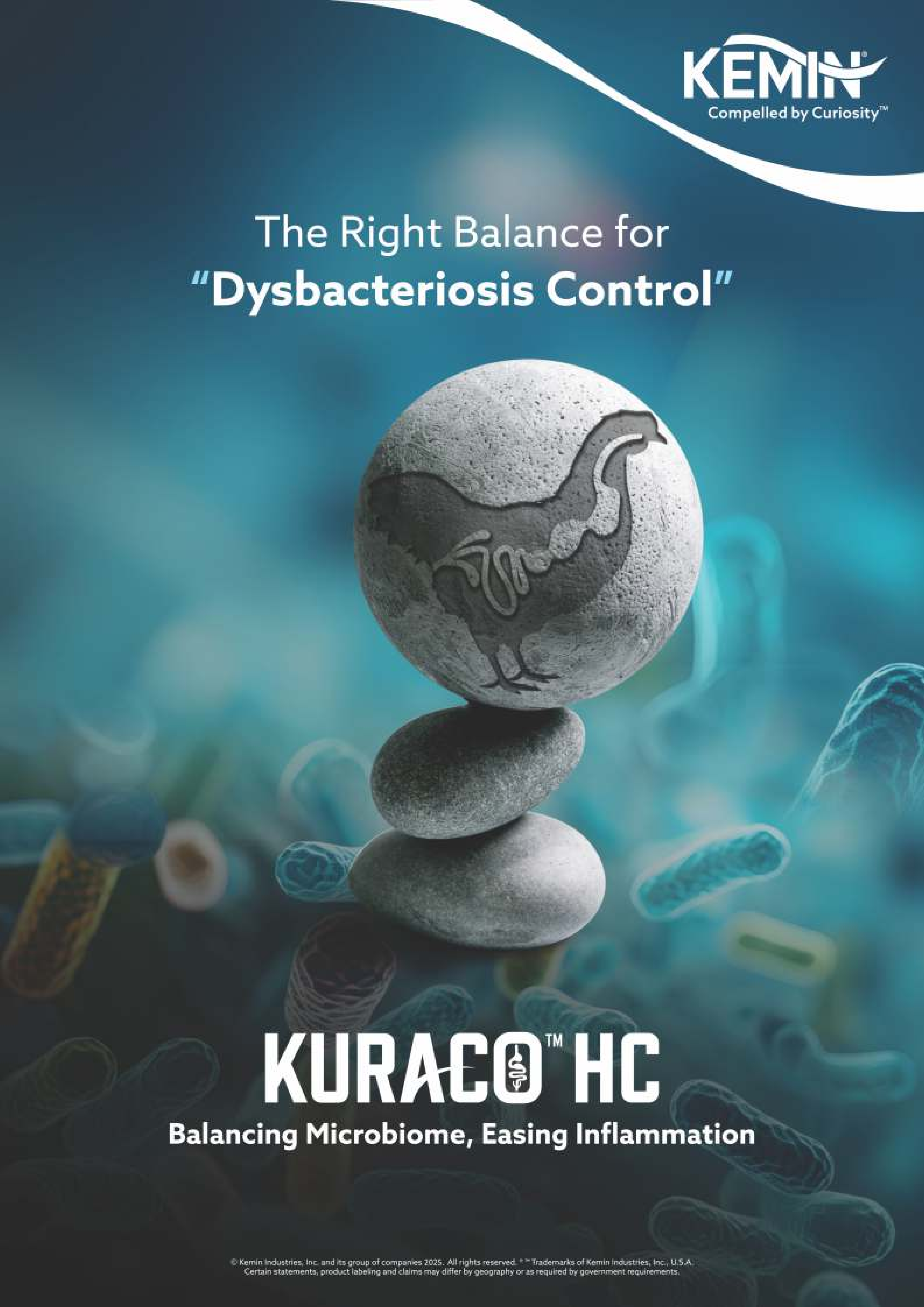
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