



Bio Vet Innovator Magazine

(Fueling The Future of Science...)

Volume 3 (Issue 3) MARCH 2026



World Tuberculosis Day - 24th March

Popular Article

Nutrigenomics: Linking Genes, Diet, and Animal Performance

Kapil Dev, Rohit Sharma* and Renuka Hada

Department of Animal Genetics and Breeding

*Corresponding Author: r20rohisharma.r@gmail.com

DOI: <https://doi.org/10.5281/zenodo.19404066>

Received: March 24, 2026

Published: March 28, 2026

© All rights are reserved by Rohit Sharma

Introduction:

Livestock production systems have traditionally relied on standardized feeding strategies to improve performance. However, animals receiving the same diet often exhibit considerable variation in growth, milk production, disease resistance, and reproductive efficiency. This variability is primarily driven by differences in their genetic makeup. Such observations have shifted scientific attention toward understanding how genetic variation influences nutritional response. This evolving field, known as *nutritional genomics*, integrates genetics, molecular biology, and nutrition to explain how an animal's genotype determines its response to dietary inputs. Rather than viewing nutrition as a uniform external factor, modern approaches recognize it as a variable whose effects are modulated by the genome. This paradigm shift is particularly relevant for achieving precision and sustainability in animal production.

Nutrigenetics and Nutrigenomics: Nutritional genomics encompasses two complementary disciplines-

- **Nutrigenetics** focuses on how genetic variations, such as single nucleotide polymorphisms (SNPs), influence nutrient utilization, metabolism, and disease susceptibility. It explains why animals with different genotypes respond differently to the same diet.
- **Nutrigenomics** examines how nutrients and bioactive food components regulate gene expression at the molecular level, influencing RNA transcription, protein synthesis, and metabolic pathways.

Together, these fields establish a bidirectional relationship: while genes determine nutritional response, nutrients can also modulate gene activity.

Genetic Architecture of Nutritional Traits:

Nutritional response traits such as feed efficiency, growth rate, milk yield, and disease resistance are typically quantitative in nature and controlled by multiple genes. These traits are influenced by:

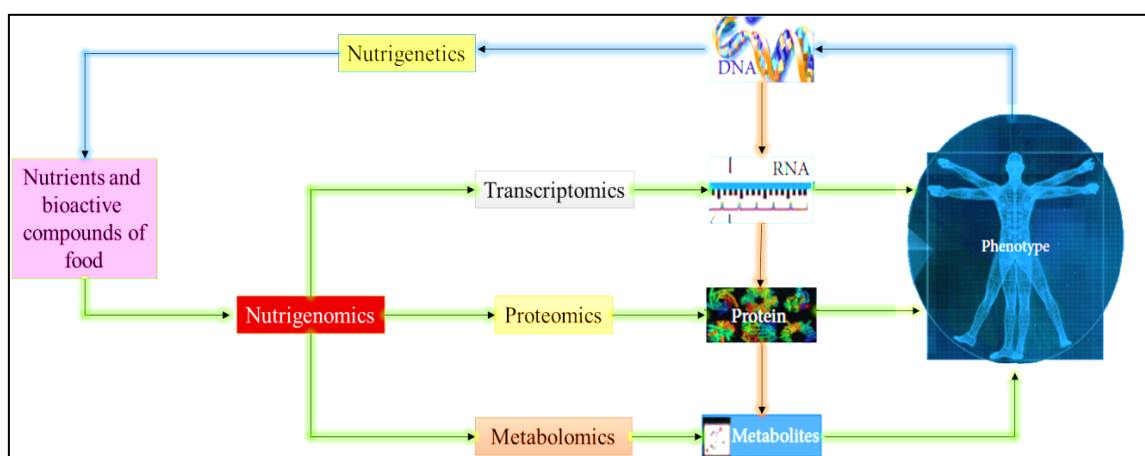
- **Polygenic inheritance**, where many genes contribute small effects
- **Quantitative Trait Loci (QTLs)** associated with metabolic efficiency
- **Genotype×Diet interactions**, where different genotypes respond uniquely to specific dietary regimes

Understanding this genetic architecture is crucial for identifying animals that can utilize nutrients more efficiently and perform optimally under varying feeding conditions.

The “Omics” Framework:

Advances in high-throughput technologies have enabled scientists to track how genetic information is translated into observable traits through multiple biological layers:

- **Genomics** identifies genetic variants (SNPs, QTLs) that influence nutrient utilization.
- **Transcriptomics** analyzes RNA expression patterns to determine how genes are activated or suppressed in response to diet.
- **Proteomics** studies protein expression and function, reflecting the functional output of genes.
- **Metabolomics** evaluates metabolites, providing insight into the final biochemical outcomes of gene–nutrient interactions.



These technologies collectively follow the biological pathway:

DNA → RNA → Protein → Metabolites → Phenotype

The integration of these datasets through bioinformatics and systems biology tools allows the identification of biomarkers and molecular pathways that can be translated into practical feeding and breeding strategies.

Role of Epigenetics and Microbiome:

An important extension of nutrigenomics is epigenetics, which involves heritable changes in gene expression without alteration of the DNA sequence. Nutrients can influence epigenetic mechanisms such as DNA methylation and histone modification, thereby affecting traits like growth, immunity, and reproduction. In some cases, these effects may persist across generations, highlighting their long-term significance. Additionally, the gut microbiome plays a critical role in mediating nutritional responses. The interaction between host genetics, microbial populations, and diet forms a complex network that influences digestion, metabolism, and immune function. Understanding this tripartite relationship represents a key frontier in precision livestock management.

Applications in Animal Health and Production:

A genetics-driven nutrigenomic approach has several practical applications:

- **Genotype-specific feeding strategies:** Diets can be tailored to match the genetic potential of animals, improving feed efficiency and reducing waste.
- **Enhanced disease resistance:** Nutritional modulation of immune-related genes can help in preventing metabolic and infectious diseases.
- **Improved reproductive performance:** Targeted nutrients can influence gene pathways associated with fertility and reproductive success.
- **Longevity and stress resilience:** Nutritional interventions can regulate genes involved in aging and environmental stress adaptation.

These applications move beyond generalized feeding practices toward more precise, genotype-informed management systems.

Implications for Animal Breeding:

The integration of nutrigenomics into animal breeding programs offers significant opportunities for genetic improvement. By identifying genetic markers associated with nutrient utilization and metabolic efficiency, breeders can:

- Implement marker-assisted and genomic selection
- Select animals with superior feed conversion efficiency
- Develop lines that are better adapted to specific feeding systems

This approach ensures that animals are not only genetically superior in terms of production traits but are also efficient in utilizing available nutritional resources.

Challenges and Future Prospects:

Despite its potential, the application of nutrigenomics faces several challenges, including high costs, limited infrastructure, and the need for advanced data analysis tools. However, rapid advancements in sequencing technologies, artificial intelligence, and precision livestock farming are expected to overcome these barriers. Future systems may integrate genomic data, real-time physiological monitoring, and diet formulation into a unified platform, enabling dynamic and adaptive feeding strategies.

Conclusion:

The integration of genetics and nutrition represents a transformative step in livestock science. By shifting the focus from generalized feeding to genotype-guided nutritional management, nutrigenomics enables a deeper understanding of biological efficiency and animal performance. This approach not only enhances productivity but also supports sustainability by optimizing resource utilization. As research continues to advance, the combined application of genomics, epigenetics, microbiomics, and bioinformatics will redefine animal breeding and nutrition, paving the way for a more precise and resilient livestock production system.