# NUTRIGENOMICS IN LIVESTOCK RESEARCH AND PRODUCTION: PRINCIPLES, APPLICATIONS AND CHALLENGES

***Okani-Onyejiaka, M. C.; [1]Etuk, E. B., [1]Ogundu, U. E.**
[1]Department of Animal Science University of Agriculture and Environmental Sciences, Umuagwo, Nigeria.
[1] Department of Animal Science and Technology, Federal University of Technology, Owerri, Nigeria
**Corresponding author's email: mirian.okani-onyejika@uaes.edu.ng*

**ABSTRACT**
*Nutrigenomics, or nutritional genomics, is a field of nutrition science that deals with the interactions between nutrients and organisms' genes about 20 relevant peer reviewed articles. Nutrigenomics uses high-throughput technologies to uncover the dietary effects of nutrients on genes responsible for phenotypic traits in livestock production. Some relevant disciplines ancillary to nutrigenomics include, nutrigenetics, transcriptomics, proteomics, and metabolomics. Its goals are to improve animal performance, welfare, health, fertility, and reduce environmental impact. However, it has not been effectively explored in the tropics due to limiting factors like 'silos' nature of research, lack of capital for elaborate studies as well as the technical complexities of the multi-omics research and ethical considerations. This paper, therefore, articulates this emerging field of nutrigenomics in livestock production; with the major focuses on; the principles, goals, techniques, applications, and challenges in livestock research and production. It is expected that researchers will be encouraged to take another look at the possibilities inherent in incorporating nutrigenomics in nutrition and genetics research in their effort to improve nutritional efficiency of livestock.*
**Keywords: Nutrigenomics, livestock, nutrition, production, genetics.**

## INTRODUCTION

The sustainability of the traditional nutritionist's interventions has been limited by their inability to comprehend the connection between nutrients and gene expression in animal productivity. According to Sales *et al.* (2014), the study of the mutual connections between nutrients and organisms' genomes is known as "nutrigenomics," or "nutritional genomics." It seeks to comprehend how dietary components, patterns of gene expression, and epigenetic changes affect an animal's genetic programming over the course of their lifetime (Wu, 2022). The goal has been to maximize animal performance, health, and product quality in recent years. This paper reviews the principles and possible application as well as the challenges of nutrigenomics in livestock production.

## METHODOLOGY

To conduct this review, a systematic search of academic databases, including PubMed, Scopus, and Google Scholar, were performed using relevant keywords such as "nutrigenomics," "livestock production," "gene expression," and "animal nutrition." Only peer-reviewed articles published in English between 2014 and 2023 were included. About 20 articles were selected based on their relevance to the topic and quality of research.

## RESULTS AND DISCUSSION

### Some Scientific Disciplines Integrated in Nutrigenomics Studies

Nutrigenomics is part of system biology which integrates information retrieved from various numbers of well-defined disciplines as follows:

**Nutrigenetics:** This is the study of genetic differences that impact how animals react to feed ingredients and nutrient intake. This information is used to optimize diets, for example, high intramuscular fat (IMF) in pigs influences pork flavor, tenderness, and juiciness (Wang *et al.,* 2020). Similarly, Malgwi *et al.* (2022) detailed the fact that fat metabolism and IMF development are under the influence of dietary nutrients, genes, and their metabolic pathways in pigs. This means that nutrition is an important epigenetic regulator that modifies gene expression without affecting DNA

sequences. Epigenetic modifications in adult phenotypes and obesity can, therefore, result from nutrient-induced changes in animals.

**Transcriptomics**: A functional genomics tool called transcriptomics examines RNA derived from the genome with an emphasis on gene expression. Accordingly, Kulahoglu and Brautigam (2014) determine how particular substances, diets, or physiological circumstances affect gene expression. It is helpful for researching economic production features and nutritional and bioactive food components.

**Proteomics:** Proteomics investigates the structures, interactions, and products of proteins. This offers nutrigenomics a comprehensive understanding of its biology. Its benefits are highlighted by studies on dietary methionine, gastrointestinal development, and pig health. For instance, researchers have evaluated the effect of dietary methionine on breast-meat accretion and protein expression in skeletal muscles of broiler chickens, while other researchers revealed the beneficial impact of colostrum on gut development and pig health using proteomics approach.

**Metabolomics:** This is a functional genomics method which looks at how food components affect the way biological systems regulate their metabolism. It facilitates comprehension of the effect of dietary changes on the health and productivity of animals, including feed efficiency and milk yield in dairy cows. Scharen *et al.* (2018) deduced that rumen microbiome plays a critical role in feed efficiency, milk yield, and components of dairy cows. Additionally, breed-associated metabolic metabolites in animals grown in identical environments have been found using metabolomics, potentially producing biomarkers for breed differentiation and improvement.

**The Goals of Nutrigenomics in Livestock Production**

The goal of nutrigenomics is to improve animal nutrition by matching the genetic backgrounds of the animals for targeted traits. An example of this is seen in the study of Nowacka-Woszuk (2019) involving the regulation of Peroxisome Proliferator-Activated Receptor Gamma Proteins (PPAR$^{\gamma}$) gene transcription to adipose cells. Again, understanding food-related expression patterns and personalized dietary approaches is another goal of nutrigenomics. According to Rodrigues *et al.* (2016), genes involved in fat tissue deposition can be modulated by dietary fats, and genomes can be influenced by dietary components. For instance, vitamin E compounds can lower telomerase activity in human umbilical vein endothelial cells (HUVEC) by lowering the expression of the vascular endothelial growth factor (VEGF) receptor. This therefore, provides a technique for improving animal diet and health.

**Nutrigenomics Techniques in Nutrition Studies**

Nutrigenomics is a relatively new approach to nutrition research that uses high-throughput experimental techniques to evaluate the response of dietary components. Microarray technology for instance is an effective tool used for global gene expression profiles and understanding factors controlling gene transcription. It allows for the evaluation of physiological effects of dietary proteins and can determine up-regulated or down-regulated genes. The integration of microarray with nutrigenomics allows for the identification of therapeutic properties of natural food compounds and understanding how certain foods may induce different gene responses. However, its major drawbacks include optimization of experimental parameters, technical variation between array platforms and analytical procedures, and the need for proper adherence to manufacturers' guidelines. In addition, microarray transcriptomics requires prior knowledge of reference genome sequences, which can inhibit the identification of transcripts from repeated sequences and de novo mRNA and non-coding RNA discovery (Kizilaslan *et al.*, 2022). Nevertheless, nutrigenomics offers a new approach to understanding the complex interactions regulating gene functions. More so, Nutrigenomics uses three major omics technologies: transcriptomics, proteomics, and metabolomics (Hag *et al.,* 2020). Transcriptomics offers better analytical advantages than microarrays, while RNA-Seq quantifies gene expression and identifies differential expression in response to specific nutrients and diets. However, proteomics is crucial as nutrients can modify RNA translation to protein while metabolomics tools detect biochemical profiles from animals fed different diets. For detection and validation of these biochemical profiles, techniques such as High Performing Liquid Chromatography (HPLC), Ultra-Performing Liquid Chromatography (UPLC), Nuclear Magnetic Resonance (NMR), spectroscopy, real-time Polymerase Chain Reaction (PCR/qPCR), and Next Generation Sequences (NGS) are employed, each with advantages and disadvantages of their own (Eryılmaz *et al.,* 2017).

**Application of Nutrigenomics in Livestock Research and Production**

Nutrigenomics has been used to develop animal feed that matches the genotypes of animals, improving health and physiological processes (Louveu *et al.,* 2016). This involves gene chips and measuring the effects of nutritional supplements. Again, nutrigenomics has been reported to help in fine-tuning nutrients by altering gene activities or selecting nutrients for fine-tuning genes and DNA present in every cell and tissue of an animal (Costa *et al.,* 2013). Nutrigenomics is particularly, useful in understanding how nutritional management can address disease, performance, and productivity in animals (Elolimy *et al.,* 2018). It has the potential to improve growth, productivity, quality, and feed efficiency in livestock, as well as animal welfare, health, and disease resistance. For example, Behrem (2021) considered using nutrigenomics to obtain effective results for the heritability of growth traits in farm animals. On the other hand, Jiang *et al.* (2014) reported how lipid metabolism in female chicken of two broiler strains could be regulated by nicotinic acid. Additionally, nutrigenomics helps in developing strategies to address limitations in reproductive performance, using oligo-based and cDNA microarray techniques to examine key reproductive, developmental, and performance characteristics in cattle. Nutrigenomic studies have been conducted on various aspects of livestock production, including swine and poultry. For instance, researchers have analyzed the transcriptome of porcine musculus semimembranosus (SM) divergent in intramuscular fat due to dietary protein restriction. This revealed a disruption in energy metabolism in muscle. Similarly, Sohel *et al.* (2018) through nutrigenomics found that a low protein diet can modulate muscle fat content but negatively impacts protein synthesis pathways, thus affecting growth. Again, Xia *et al.* (2021) reported that dietary inulin supplementation significantly modified the liver transcriptomic profile of broiler chickens, improving performance and immunity. In the same vein, Qu *et al*. (2019) identified candidate genes involved in spermatogenesis regulation in sheep testis following dietary vitamin E supplementation. The study explored vitamin E's role in sheep spermatogenesis and its potential negative effects which showed that vitamin E supplementation altered gene expression, with larger doses reducing skeleton and Extra-cellular matrix (ECM)-related gene expressions.

**Challenges of Nutrigenomics Utilization Livestock Research and Production**

The number of nutrigenomic studies conducted in the tropics is low due to several challenges. These include a lack of critical knowledge of genome-nutrient interactions in systems biology, technical complexity, and difficulty in interpreting research outcomes (Kizilaslan *et al.,* 2022). For instance, systems biology uses nutrigenomics data but faces capacity deficiency among researchers, leading to a bias in researchers' ability to judge significant gene expression changes. Again, the availability of genomic information is crucial for determining specific nutrient under specific conditions; Also, its use is questionable due to financial, ethical, and customer preference prospect (Derecho, 2023). Non-robust statistical models and analytical methods are also challenges in integrating and interpreting multi-omics data. To evaluate current phenotypes, precise, accurately measured, representative, and easy/cheap-to-measure phenotypes are needed, as variation in response to dietary interventions could pose noise that could affect the utility of the outcomes of the intended studies (Gibney *et al.,* 2020).

**Conclusion**

Nutrigenomics is used in various livestock sectors, but its application in the tropics has not been fully documented due to capacity deficiency. Despite this, nutrigenomics holds promise for improved growth, production, meat quality, and feeding in the livestock industry.

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