



Nutrigenomics: Personalizing Nutrition for Better Health

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Abstract

Nutrigenomics is a rapidly evolving discipline that examines how dietary components influence gene expression and how genetic differences affect individual responses to nutrients. With advancements in omics technologies, researchers are gaining deeper insights into molecular interactions between diet and the genome, enabling the development of personalized nutritional strategies. This approach has significant potential in reducing the risk of chronic diseases such as obesity, diabetes, and cardiovascular disorders by tailoring dietary recommendations. Furthermore, nutrigenomics supports the design of functional foods aimed at specific metabolic pathways. However, challenges including complex gene–environment interactions, limited clinical evidence, and ethical concerns related to genetic data remain.

Keywords: Functional foods, Nutrigenomics, Personalized nutrition, Precision nutrition

Introduction

In the era of personalized health and precision medicine, nutrition science is undergoing a major transformation. Traditional “one-size-fits-all” dietary recommendations are gradually being replaced by more targeted approaches. Nutrigenomics, an emerging field at the intersection of nutrition and genetics, is playing a key role in this shift by exploring how diet interacts with our genes to influence health. Nutrigenomics is based on data that over a period of exposure to certain nutrients which affects gene expression, as a result one can able to adapt changes in environment and chances surviving in different environment were observed.

What is Nutrigenomics?

Nutrigenomics is a rapidly advancing discipline that investigates the molecular interactions between dietary components and the genome, with a focus on how nutrients modulate gene expression and influence metabolic pathways (Chaudhary *et al.*, 2025). It

integrates principles from molecular biology, nutrition, genomics, and bioinformatics to elucidate the role of diet in health and disease at a genetic level. Nutrigenomics works on two hypotheses. One is nutrients directly affects the health of an individual and affect crucial metabolic pathway through gene expression. Second is alteration in biochemical reactions due to cofactors involved in enzyme reactions at cellular level and uptake of certain nutrients. The very good example for uptake of nutrient is certain food, which we change over a time.

Can Food Talk to Our Genes?

Food is not just a source of energy but also a regulator of gene activity. At the cellular level, nutrients and bioactive food compounds act as signaling molecules that regulate transcription factors and gene expression patterns. These interactions can alter key biological processes such as inflammation, oxidative stress, lipid metabolism, and energy homeostasis. Techniques such as transcriptomics, proteomics, and metabolomics are widely employed to study these complex interactions and identify biomarkers associated with dietary responses (Dey and Kumar, 2022).

Genetic variability, particularly single nucleotide polymorphisms (SNPs), plays a critical role in determining individual responses to nutrients. Such variations can influence nutrient absorption, metabolism, and utilization, thereby contributing to differences in disease susceptibility among individuals. Nutrigenomics thus provides a scientific basis for personalized nutrition, where dietary recommendations are tailored according to an individual's genetic profile. Functional foods like dietary fibers, polyphenols, and essential fatty acids influence the metabolic activity associated with obesity, insulin sensitivity, blood sugar level and fat metabolism and help in reducing associated lifestyle diseases. For instance, Methylene tetrahydrofolate reductase is example of an interaction of nutrient- gene interaction, which helps in risk of cancer. Angiotensin-converting enzymes helps in reducing blood pressure and glutathione S-transferases help in prevention of cytotoxic and mutagenic mutations (Lam *et al.*, 2025).

Role in Food Industry

The food industry is increasingly using nutrigenomics to develop functional foods and nutraceuticals. These products are designed to deliver specific health benefits by targeting gene expression and metabolic pathways. Personalized nutrition products tailored to individual genetic profiles are becoming a popular trend, creating new opportunities for innovation in food processing and product development.

Diet plays a crucial role in cancer prevention, particularly through bioactive compounds such as omega-3 fatty acids, vitamins, phytochemicals, and minerals, which can influence gene

expression by interacting with DNA (Shaman, 2024). Thus, the relationship between diet and genetics can significantly impact the risk of developing cancer. Food industries should shift their focus away from producing ultra-processed foods and products high in fat, salt, and sugar. Instead, they should concentrate on creating probiotic, functional, and nutraceutical foods, as well as adhering to the DASH diet principles. Various advanced techniques, such as nanoemulsion, nanotechnology, microfluidization, non-thermal technologies, green extraction methods, membrane technology, and 3-D printing, can be employed in food manufacturing to enhance product quality and health benefits.

Advantages of Nutrigenomics

Nutrigenomics offers several benefits, including the ability to provide personalized dietary recommendations, improve disease prevention strategies, and enhance overall health outcomes. It also supports the development of targeted functional foods and helps bridge the gap between nutrition science and molecular biology. Currently, nutrigenomics is focused towards metabolic disorders, newborns with inborn metabolic errors, and monogenic disorders in adults.

Challenges and Limitations

Despite its potential, nutrigenomics faces several challenges. The most significant challenge is the requirement of individual genetic information and concern over the validity of test and risk association. With it the complexity of gene–diet interactions, high costs of genetic testing, and limited clinical validation restrict its widespread application. Additionally, ethical concerns related to the use and privacy of genetic data must be carefully addressed.

Conclusion

Nutrigenomics offers a transformative approach to understanding the role of diet in regulating gene function and provides a foundation for developing individualized dietary strategies aimed at improving health outcome.

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