

NUTRIGENOMICS

Abstract

Recent developments in the field of nutrigenomics are advancing nutrition research and creating new paradigms. "Nutrigenomics" is the application of genomic principles to the discovery of associations between certain nutrients and genetic variables. Addressing the risk factors for chronic degenerative diseases linked to nutrition is crucial in order to address the underlying mechanism of hereditary predisposition. The development of a profound understanding of genetic variations and gene expression patterns has been made possible by advances in the sciences related to the study of genes. This understanding has helped to develop treatment responses for chronic degenerative disorders linked to public health. Nutrigenomics information aids in developing individualized nutrition plans for disease treatment and disease prevention.

Key words: nutrigenomics, nutrition, gene, degenerative disorders.

Introduction:

The emerging field of nutrigenomics **informs** us what particular meals signal to your genes. The genetic signals that reach the human body are directly influenced by what they consume. The relationship between dietary factors and inherited genes, sometimes known as nutritional genomics or nutrigenomics, was originally described in 2001 (Peregrin, 2001). "Nutritional genomics, commonly referred to as nutrigenomics, is a field of study that **explores** the relationship between the human genome, diet, and **health**".

Comment [OC1]: Use another synonym as "advice".

"Nutritional genomics" is a catch-all phrase that encompasses a number of subcategories, including nutrigenetics, nutrigenomics, and nutritional epigenetic. Each of these explains a different component of how genes respond to nutrition and express particular phenotypes, such as risk for disease (Camp & Trujillo, 2014).

Human health and the emergence of chronic diseases including cancer, osteoporosis, diabetes, and cardiovascular disease are both significantly influenced by nutrition and genetics. The term "nutrigenomics" refers to a scientific method for examining the impact of diet on health that combines nutritional sciences with genomics and makes use of other high-throughput 'omics' technologies including transcriptomics, proteomics, and metabolomics (Shade *et al.*, 2017). This novel research demonstrates that:

- The consequences of dietary bioactive substance on gene expression
- What we eat affects the way our gene function
- How nutrients affects genes to treat and prevent diseases
- Molecular connection between foods and gene responses

Researchers have started to look at these nutrient-gene synergies at the fundamental molecular level virtually over the last two decades, despite the fact that the genetic component had previously been thought to be a factor that controls variability in dietary response.

Nutrigenomics:

A branch of nutritional genomics called nutrigenomics investigates how food choices affect gene expression. The field of nutrigenomics focuses on how dietary components, including nutrients and non-nutritive bioactive substances like enzyme inhibitors, influence gene expression, protein and metabolite concentration, and consequently metabolism, health status, and disease risk. This may sound difficult to understand, but it can probably be done by using some of the well-known nutrigenomics examples. For instance, the presence of resveratrol in red wine has helped it to become somewhat of a modern-day health food. A vitamin called resveratrol activates a gene that guards against free radical damage to tissues. The nutrient folate, which is present in foods like fruits and green vegetables, is another one that influences your DNA. Folate is required by the body to create DNA. Cancer is more likely to occur in people who do not consume enough folate (**Debusk *et al.*, 2005**).

Comment [OC2]: Use a synonym as "protects"

Although widely acknowledged, the presence of numerous bioactive substances in the typical diet that can interact with receptors to either directly alter chromatin structure or indirectly activate or modulate the transcription of target genes is rarely taken into account in the planning and analysis of genetic and epidemiological studies.

Comment [OC3]: Too long, you can use two or three paragraphs.

These are the Fundamental Five Concepts of Nutrigenomics:

1. Micronutrients and macronutrients included in the diet can modify the structure and expression of genes in the human genome, either directly or indirectly.
2. The food can have a significant role in the development of a number of diseases under specific conditions and in some people.
3. The development, incidence, progression, and severity of the disease are likely significantly influenced by several genes that are controlled by nutrients in the diet.
4. Genetic make-up may have an impact on how much nutrition affects the balance between health and disease.

5. Individualized nutrition, which is based on an understanding of each person's nutritional status, needs, and genetics, can be used to prevent, treat, or mitigate chronic diseases.

Nutrient-gene Interaction:

For conceptualizing nutrient-gene interactions, there are three main groups:

1. **Direct Interaction:** Sometimes foods act as transcription factors that can bind to DNA and abruptly trigger gene expression after connecting with a receptor.
2. **Epigenetic Interaction:** Nutrients can change the structure of DNA or the histone proteins in chromatin, which results in a long-term change in gene expression.
3. **Genetic Variations:** SNPs, or single nucleotide polymorphisms, are frequent genetic differences that can change how genes express themselves or function.

All of these pathways have the potential to modify nutritional needs and metabolism. Either directly or indirectly, dietary substances can influence gene expression.

Nutrigenetics:

It studies on how a person's genetic make-up affects their body's reaction to the nutrition they consume. Additionally, persons are thought to be gene variants. For instance, minor genetic variations across individuals led to various reactions to specific foods. Certain combinations can trigger the onset of particular illness disorders depending on the foods consumed. Genetics is the study of genes, inherited substances that are passed down from one generation to the next. The proteins in our bodies are made by genes, which also determine individual variances (**Breitbart *et al.*, 1987**). With the use of nutrigenetics, we can understand how our genes influence how we respond to certain foods, beverages, and supplements. It has long been evident that different people respond to certain foods in different ways. For instance, whereas some people can consume dairy products without issues, those who have lactose intolerance experience gastrointestinal discomfort after consuming specific dairy products. Patients with lactose intolerance are those who cannot digest the natural sugars found in milk products (**Murgia *et al.*, 2017**). In people with lactose intolerance, the gene that produces lactase is turned off. The lactase-producing gene is disabled in patients with lactose intolerance.

Comment [OC4]: Add: the enzyme that —

Nutrigenetics' ultimate objective is to generate dietary recommendations for people based on their genetic makeup. Regarding dietary genomics, there are crucial considerations. The first is to acknowledge that for some people, diet poses a serious danger for developing a number of ailments. Furthermore, common food components can influence the human genome directly or indirectly to alter gene expression or

structure. However, a person's genetic makeup may play a role in how much their food alters the balance between healthy and disease-related conditions. Additionally, the majority of diet-governed genes are anticipated to play a role in the development, progression, and severity of chronic diseases. Thus, "personalized nutrition" can be utilized to treat, or prevent chronic diseases (Pavlidis *et al.*, 2015).

Nutrients Works as Gene Switches:

Researchers have used rat models and cell culture research to test the impact of illness prevalence, gene expression, and dietary consumption (Uthpalaet *et al.*, 2021). Alterations in DNA methylation are linked to certain diseases that are becoming more prevalent. Foods high in methyl donors, such as betaine, choline, methionine, folate, vitamin B12, and foods like garlic, beets, and onions, are converted into energy to facilitate DNA methylation (Shorter *et al.*, 2015). Agouti-carrying mice are more ravenous and obese due to a mutation that turns them yellow instead of brown. Their susceptibility to consequences like diabetes and cancer, among others, was caused by the existence of this gene.

Table: The Association between Whether Nutrition Affects Genes and Diseases

Comment [OC5]: Search another word.

Nutrient	Gene impact	Related disease	Reference
Folic acid	DNA methylation	Cancer	Pufuleteet <i>et al.</i> , 2005
Fatty acids	Bind to transcription	Obesity	Hotamisligil <i>et al.</i> , 1996
Vitamin D	mRNA stability	Kidney disease	Davis <i>et al.</i> , 2011
Vitamin E	Radiation mimic (DNA oxidation)	Cancer, heart disease	Kaput <i>et al.</i> , 2004
Flavones	Increases mRNA synthesis induce DNA fragmentation	Arthritis	Li & Zheng. 2019
Niacin	Disables DNA repair (poly ADP ribose)	Cancer	Abotaleb <i>et al.</i> , 2018

Nutrigenomics and Diabetes:

The number of people with diabetes is expected to increase from 387 million to 592 million by the year 2035, having an impact on all people worldwide (Vyas *et al.*, 2022). Type I diabetes (T1DM), which is characterized by cell loss and insufficient insulin secretion and is caused by the death of pancreatic islets by T lymphocyte infiltration, is the less frequent and more complicated form of the disease, while type II diabetes (T2DM), which makes up more than 90% of cases, is more common. People between the ages of 40 and 59 are most commonly affected by diabetes mellitus. The development and pathogenesis of the disease are significantly influenced by a wide range of variables, including metabolic profile, genetics, diet, and environmental changes. With the use of omics techniques, which facilitate the

identification of targets like proteins, genes, and their interactions with nutrients, the effect of dietary components on gene activity was examined (Ovesná *et al.*, 2008).

In order to understand the etiopathogenesis of various metabolic illnesses, it is imperative to look into nutrient-gene interactions. These elements can control the expression of genes by altering signaling molecules in intricate metabolic processes. A genomics study discovered that 65 (SNPs) are related to the likelihood of having Type 2 Diabetes. Testing for the detection of (SNPs) associated with Type II Diabetes has recently been more accessible to people thanks to advancements in human genome decoding and genome sequencing, allowing patients to learn about their genetic susceptibility to the disease's development (Vorderstrasse *et al.*, 2013).

Comment [OC6]: Delete parenthesis.

Nutrigenomics and Cardiovascular diseases:

In 2012, 17.5 million fatalities were attributed to cardiovascular illnesses; according to the World Health Organization. In situations of Cardio Vascular Diseases (CVD), intimal lesions develop as a result of cell death, lipid build-up, pus cells, blood cells, fibrosis, and inflammatory reaction in blood vessels. Treatment and prevention of cardiovascular disease both benefit from proper nutrition. A nutritious diet can influence the expression of several genes that are involved in metabolism and lipid production, including the peroxisome proliferator (PPAR), fatty acid synthetase (FASN), lipoprotein lipase (LPL), arachidonate 5 lipoxygenase (ALOX5), and apolipoprotein E (APOE). The susceptibility of an individual to cardiovascular illness can be changed by variations in the genes that code for different enzymes, hormones, and apolipoproteins (Pagidipati *et al.*, 2013). Evidence-based studies have shown that the arachidonate 5 lipoxygenase (ALOX5) gene affects the production of leukotriene, chemokines, and cytokines because elevated levels of it have been observed in people with atherosclerotic lesions, which suggests an increase in the mobilization of inflammatory cells. Leukotriene development is prevented by eating a diet high in omega 3 polyunsaturated fatty acids, which change eicosanoid biosynthesis (Ferretti *et al.*, 1997). Polyunsaturated fatty acids (PUFA) support the metabolism of lipids and carbohydrates by affecting the expression of several genes. Patients who consumed these essential fatty acids, therefore, had decreased LDL (low-density lipoprotein) cholesterol levels.⁵⁷ In some ethnic groups, such as African-Americans, a polymorphism (-504 cc) in the hepatic lipase gene increases protective HDL levels in response to a high-fat diet. By altering the fluidity of the membrane or by producing alternative ligands, PUFA regulates gene expression. The aforementioned justifications suggest that dietary changes may be used to treat cardiac diseases depending on a person's genotype (Tai & Tan, 2004).

Nutrigenomics and Obesity:

One of the main metabolic anomalies is obesity, a disease associated with nutrition that dramatically increases susceptibility to degenerative diseases. As a result, a person's tendency for obesity is determined by the management of the energy balance in genetically predetermined patterns. Research has shown that genetic factors account for about 80% of the variations in the Body Mass Index (BMI) of twins. Additionally, several peripheral signaling peptides like cholecystokinin, leptin, insulin, and ghrelin, as well as some related genes encoding taste receptors, influence food intake control due to polymorphisms in the genes and have a direct relationship to weight management. The polymorphic traits of the genes involved in modulators of energy expenditure encoding have a significant role in the control of adipocyte development and differentiation as well as protein uncoupling. A polymorphic central regulator of energy intake is made up of elements of the melanocortin pathway, hypothalamic neuropeptide Y, and other important neuropeptides (Loktionov, 2003).

Nutrigenomics has the potential to control the chronic inflammation that occurs in obesity. Some foods contain anti-inflammatory bioactive chemicals such as quercetin (greens and fruits), caffeic acid (yerba mate), lycopene (guavas, melons, and tomatoes), and tyrosol (fruits and vegetables) (olive oil). These bioactive substances prevent some genes from being expressed. Tocopherol, an antioxidant found in green tea, has been shown to have anti-inflammatory properties and to be quite successful in protecting obese people. This substance may therefore be helpful in the treatment of obesity (Shamim & Gupta 2017).

Functional foods and Nutrigenomics:

Functional foods are defined as food sources that contain specific nutrients or non-nutrients that have a specific impact on a person's body functions and also ensure a proper supply of nutrients, facilitating functional and nutritional benefits. The concept of functional foods first emerged in Japan in the 1980s. In 1999, it was further explained. Functional foods are defined as naturally occurring foods that are high in vitamins, minerals, fatty acids, phytosterols, and antioxidants. The food business is currently focused on creating functional foods that reduce calories, lower glycemic index, and have lower fat content (García-Casal, 2007).

Conclusion:

The food industry is currently focused on generating functional meals that cut calories, lower glycemic index, and have lower fat content. Functional foods are defined as naturally occurring foods that are high in vitamins, minerals, fatty acids, phytosterols, and antioxidants. This branch of science examines how genetic variability affects dietary recommendations or the relationship between diet and

disease. The long-term aim of nutritional research is to enhance a person's health and aid in illness prevention, even though their immediate goals are different.

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