ISSN: 2347-467X, Vol. 10, No. (3) 2022, Pg. 1092-1104

Current Research in Nutrition and Food Science

www.foodandnutritionjournal.org

Advances in Nutrigenomics and Applications in Public Health: A Recent Update

SWATI VYAS

Department of Home Science, IIS deemed to be a University, Jaipur, and Rajasthan, India.

Abstract

Nutrition research is achieving new paradigms through recent advances in the field of Nutrigenomics. The application of genomic principles for the identification of relationships between certain specific nutrients with genetic factors is termed “Nutrigenomics”. This knowledge is essential to understanding the risk factors behind diet-related chronic degenerative diseases, which further helps resolve the underlying mechanism of genetic predisposition. Advances in Sciences associated with the study of genes have assisted in developing a deep insight into genetic variants, and gene expression patterns to work out therapeutic responses toward chronic degenerative diseases associated with Public Health. To appraise recent advances in Nutrigenomics with its application in Public health several databases including Pub Med, Google Scholar, Medline etc were investigated in detail. A total of 72 relevant peer-reviewed journal articles were included in this review paper. Nutrigenomics has an important role in comprehending how homeostatic control is maintained and the way metabolic pathways are influenced by nutrient intake. The knowledge of Nutrigenomics helps in working out personalized nutrition strategies for both prevention and management of the diseased situation. The present review article aims to investigate and present a piece of in-depth information about the latest Advances in Nutrigenomics and its application in public health.

Article History

Received:03 July 2022

Accepted: 08 November 2022

Keywords

Chronic Diseases;
Functional Foods;
Nutrigenomics;
Personalized Nutrition;
Public Health.

Introduction

The recent emergence of the Omics era has resulted in an upsurge of the new term “Nutritional Genomics”. The Nutritional genomic area is divided into two parts, first Nutrigenomics ie the study of the interaction between the genetic material with the dietary components and associated regulations in the metabolism of nutrients mainly proteins, second is Nutrigenetics which identifies responses related to dietary components about genetic differences.[1] Nature is the source of various nutrients which are available to us through diet and have constant

CONTACT Swati Vyas swativramani@gmail.com Department of Home Science, IIS deemed to be a University, Jaipur, and Rajasthan, India.

Doi: http://dx.doi.org/10.12944/CRNFSJ.10.3.23

interaction with genetic material as demonstrated by the metabolism of our De oxy Ribonucleic Acid with a wide range of Dietary factors acting as cofactors in the pathway of metabolism.[2]

Thus Nutrigenomics is an application of genomics in nutrition[3] it became an evident field of science by unrevealing interrelationships linking nutrients with human genomic structure and health thereby employing the newest tools including transcriptomics, epigenomics, metabolomics, and proteomics.[4,5] The impact of bioactive chemicals on gene expression, how our nutritional intake affects the pathway of our genes, and how it can be regulated for the treatment and prevention of diseases are all revealed by this developing research.[6] The interaction of nutrients with genes about specific health and disease concerns provides us with the latest information about the way specific processes in intermediary metabolism are regulated by genes providing an in-depth understanding of certain diseases like obesity, diabetes, and cardiovascular diseases having both nutrients as well as genetic components.

Methods

Several Electronic Databases were Searched

Medline, Cochrane Library, Scopus, Science Direct, Health Internetwork Access to Research Initiative up to January 2022. Certain keywords used for searching the articles were Nutrigenomics, Nutrigenetics, Public Health and Nutrigenomics, Diabetes, Obesity, Cardio Vascular Diseases and Nutrigenomics, Nutrigenomics, and Functional foods, etc.

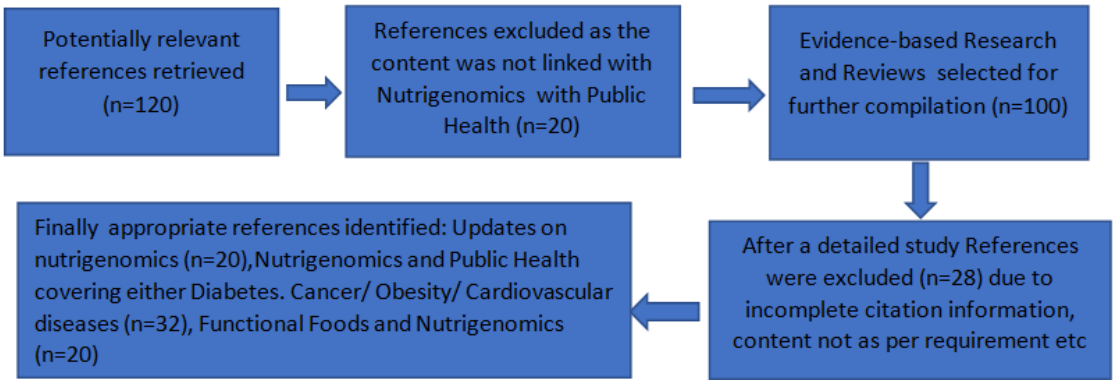

Fig 1: Selection of Research based on the topic of Review

Update on Nutrigenomics and Nutrigenetics

De Oxy Ribonucleic Acid (DNA) and genetic code influences our nutritional needs and this information aids in the determination of exact amounts of essential nutrients that aid in the maintenance of health. It also aids in explaining the diet-gene interaction, which determines the effect of nutrition in promoting positive health outcomes.[7,8] As a result, we can gain a better knowledge of how people with various genetic makeup react to different diets, which will aid in the development of technology aimed at matching people to the foods that best suit them. [9,10] By using genomic principles in nutritional research, we can create connections between specific nutrients and genetic characteristics, such as how diet or food additives affect gene expression. Knowledge of Nutrigenomics thus facilitates the development of a deeper insight into the impact of nutrition on the metabolic pathway.[11] Thus this field of research aims to identify the influence of genes with a focus on the risk of developing diet-related diseases including the mechanisms which form the basis of these genetic predispositions.[12]

It also clarifies the etiological framework of certain nondegenerative diseases including Non-Insulin Dependent Diabetes, Cancer, Obesity, and Cardiovascular Disorders (CVD).[8,11] Nutrigenomics also aids in relating genes with diet detection of polymorphisms with associated nutritional implications and the impact of environmental factors on their expression. Precisely this field of science

assists in the impact evaluation of nutrients and several other bioactive components on genes and finally their consequence on human health. Nutrigenomics refers to the study of a biological system using functional genomic methods to learn how dietary components influence the pathways of metabolism and their associated homeostatic control thereby ensuring optimum diet form through a series of nutritional modifications.[13,14]

Nutrigenetics provides essential information to help clinicians determine the best specific diet for an individual.[13] Nutrigenomics research employs transcriptomics, proteomics, and metabolomics technologies. The expression of genes is affected at multiple levels by nutrients and this includes regulation of genes, signal transduction, chromatin structure as well as protein function.[14] It also analogous to how food affects the anatomical growth and development which takes place under genetic influence. This profiling is used to discover individual variances in dietary requirements as well as the ability to respond to food-related therapies. Nutrigenetics looks into the impact of genetic diversity on the interaction between nutrition as well as associated disease, as well as dietary recommendations.[12] Nutrigenetics focuses on the genetic makeup of an individual as influenced by his/her nutrient intake.[13] The study of gene-nutrient interactions is still in its early stages. Both monogenetic diseases, as well as polygenetic diseases, are influenced by individual genotypes of unsuitable food.[15,16] Enzymatic activity variations, which impact circulation and the effectiveness of chemicals and their metabolites, are influenced by genetic polymorphisms.[14] Furthermore, metabolic illnesses like Phenylketonuria, abnormalities linked with oxidation of fatty acids, and hemochromatosis can be managed well via dietary limitations as worked out based on genetic makeup.[17] Nutrient-nutrient interactions can occur depending on meal consumption patterns, which can lead to the onset of certain illnesses and disorders.[3,18] Certain people with reported deficiency of lactase enzyme may complain of intolerance towards lactose sugar which might reciprocate in gastrointestinal discomfort after consuming dairy products[10,18] on the contrary, others might consume them without experiencing abdominal pain, or bloating, diarrhea, or malabsorption.[18] This paves the way for "personalized nutrition," which could have a real-world scientific application in the prevention, mitigation, or cure of certain chronic diseases.[4]

Genetic Bases of Nutrigenomics and its Correlation with Diseases

New 'omic' technologies are based on deep understanding of nutrition, genetics and biochemistry. These technologies can be applied to investigate nutrient-gene interaction as well as underlying mechanism which forms explanation of genetic basis of interindividual differences in relationship to nutrient intake.

Although Recommended Dietary Allowances (RDA) or Safe upper Limits guide us in planning diets but are not based on the individualized metabolic outcome, not even optimized for specific genetic subgroups thereby differ significantly in transport protein activity. It is important to match the nutrient intake combination ie the nutriome to the existing genome status that may be either inherited or acquired genome to ensure regular and sustainable maintenance of the genome, gene expression metabolism, and also cellular functions.[15,7,8, 11,12] Personalized nutrition plans empower patients and by adopting them they don't need to endure unappealing, unsuccessful diets when there is the potential for a more beneficial alternative. Tailored dietary interventions designed for both prevention and management of chronic degenerative diseases keeping genetic composition as a basis have proved to be quite effective.[21,22]

During this era of nutrigenomics the researchers have examined the impact of genes and genetic variations on the requirements of nutrients. In research, animal-based models have wider applications in which system-based biology methodologies can be utilized and these factors have a specific effect on gene pathways. However, utilizing nutrigenetic techniques is becoming increasingly viable to develop a deeper understanding of the genetic foundation associated with the health or diseased condition which further facilitates the adoption of the realistic approach to developing a customized diet.[23]

Table 1: Aspects to be considered while working out personalized nutrition ie Precision Nutrition Strategy

Sr No	Aspects	Impact
1.	Genetic Variation	Different ethnic groups and individuals have varied genetic makeup and this has a direct impact on nutrient absorption and metabolism.[8]
2.	Diverse economic and Geographic conditions	This aspect has a direct bearing on the accessibility of nutrients besides these personal choices and perceptions related also affect food or nutrient availability.[11,12]
3.	Nutritional Status	Gene expression and stability correlates with the nutritional status as both under and overnutrition have an impact on the sequence of genes and also on the structure of chromosomes, and this further influences the gene dosage and its expression, as well as undesired phenotypes at different stages of life.[19]
4.	Variability at the individual level	Variability in dietary absorption, metabolism, disposal, and food nutrients do not acquire the same levels in the individual's tissue or blood sample. The mechanisms that drive diet-based response in persons of varied races and ethnicities are complex and poorly understood. These factors influence body weight, blood pressure, and cholesterol levels differently amongst individuals.[20,21]
5.	Miscellaneous factors	The other factors include gender differences, individuals' and activity levels along with genetic composition and behavioral aspects, etc and aim of nutritional genetics is to assist people to eat better.[19]

Thus the latest advancement is towards designing nutritional recommendations based on analysis of data on the variation of genes, lifestyle as influenced by diet, behavior, and physical activity, as well as the environment, and this information, is utilized in working out nutritional recommendations often in the form of Single Nucleotide Polymorphism (SNPs) , but not solely.[24,25] It is important to apply both bioinformatics as well as protein studies in discovering novel gene proteins also their nutrient connections and the reason behind disease causes. Analysis and interpretation of data sets associated with gene interaction with selected food require a combination of statistics and bioinformatics with the biological aspect. Pharmaceuticals are frequently used to restore health in a targeted manner, whereas dietary treatments are usually used to maximize health in a multi-parametric manner. According to a survey of the literature, approximately 1000 genes have been linked to human disorders, with 97 percent of these resulting in monogenic diseases which result from a single gene having some defect on the genomic scale thus resulting in disease onset. Lactose intolerance is the most well-known example of this, in which a genetic change in the lactase gene causes insufficient lactase production in the small intestine. Those who suffer from lactose intolerance report the inability to digest lactose present in dairy products thus foods that contain lactose have to be omitted from the daily regime and switch to products that are lactose-free to avoid gastrointestinal distress.[26, 27]

Nutrients are widely regarded as the most powerful environmental stimulus, throughout their lives, genomes are exposed to a variety of environmental stressors, including diet. As a result, minerals and phytochemicals included in the diet have a significant impact on DNA expression. Dietary imbalances can result in interactions of genes and nutrients thereby

stimulating the incidences of chronic degenerative diseases with a direct or indirect effect on genome expression.[15] A wide range of dietary components acts as cofactors or substrates in the metabolism and repair of DNA. Nutrients influence the development of the specific phenotype however specific individual genotype reaction toward specific nutrients needs to be addressed. Genetic code is an important factor in the determination of stability of the genome as well as its health outcomes including abnormalities related to development, degenerative illness, and cancers.[2]

Environmental and genetic variables have a role in the etiology of complicated chronic disorders. El-Sohemy propagated the "fetal basis of adult disease" and also "early origins theory" which proposes that gene expressions are influenced by both nutrition and other environmental variables besides this cellular plasticity is also affected by these factors, particularly during the prenatal and postnatal development phase.[28] The concept of nutrients' impacts on DNA integrity, repair, and various gene expression mechanisms has only lately gained traction in nutritional science.[29] Numerous dietary components can influence health by altering genetic and epigenetic events.[25] Single Nucleotide Polymorphism (SNPs) have been reported to be the most popular genetic variant throughout the human genome and this has been confirmed in 1 percent of the human population. Furthermore, SNP analysis can be used as a molecular tool to investigate the function of human health disease and nutrition as well as to identify optimal diets.[30]

At Two Levels, Nutrients and the Genome Interact

- Nutrients can modify individual phenotypes by inducing or repressing gene expression.
- Single nucleotide polymorphisms, on the other hand, can affect the ability of certain nutrients to interact with them, mediators of certain metabolic pathways, and also their bioactivity.

Among the variety of options available Nutrigenomics will help in selecting the best option on the other hand nutrigenetics will help in creating data that may be used to identify the best diet for a specific subject, i.e. individualized nutrition.[21]

The Hypothesis Behind the Research of Nutrigenetics and Nutrigenomics

- Nutrition can affect health outcomes directly by changing gene expression in important pathways regulating metabolism which in turn might affect genetic mutations at the basic chromosomal level thereby resulting in a change in dosage of gene and expression too.[21]
- Health impacts of nutrients and nutriomes can be influenced by genetic factors which influence nutrient absorption and metabolism along with molecular interactions of certain enzymes with their nutrient cofactors.[21]
- Nutrients and phytochemicals present in food sources significantly affect gene expression and during the entire lifespan, approximately 16 genomes reflect themselves in different ways because of their exposure to various environmental stimuli.[15]

Nutrients can alter a wide range of individual genes by activating receptors ie nutrition sensors that actively behave as transcription factors helping in binding nutrients and other metabolites, for example, vitamin D receptors attach to Vitamin D however peroxisome proliferator-activated receptors (PPARs) bind to a fatty acid.[12]

To better comprehend the rationale for the relationship between foods as medicine and improving human health, multidisciplinary impacts are required. Many studies have shown that certain dietary ingredients may have anti-inflammatory qualities. Now is the time for research into the range of foods that can alter gene expression implicated in inflammation, which might be a major advance in the field of nutrition science. Free radicals of oxygen with reactive chemical characteristics,a superoxide anion radical (O_2), Hydroxide (OH) is extremely reactive, and (O_2) ie singlet oxygen, and also Hydrogen Per Oxide (H_2O_2) are known as Reactive Oxygen Species (ROS) (non-radical molecules). They can be produced in cells by both endogenous and external sources. Excess Reactive Oxygen Speciess alters the essential equilibrium of the intracellular redox state, leading to oxidative stress, biochemical antioxidant depletion, or both. The rate of pro-oxidant

(either exogenous or endogenous) formation and the cellular enzymatic and non-enzymatic antioxidant milieu are significant factors in intracellular redox status.[32,33,34,35]

Cancer and Nutrigenomics

Cancer is a complicated disease characterized by abnormal gene expression, protein and metabolite functio. Many malignancies, according to scientific data, are avoidable by proper management of diet and nutrition as they help in managing variables in cancer risk reduction.[36] In approximately 70 percent of cases of cancers, almost 35 percent of human malignancies are correlated with faulty dietary habits.[37,38] The deficiency of specific nutrients which act as cofactors of DNA repair enzymes and also in the DNA oxidation prevention uracil incorporation in DNA can be confirmed by certain genome and epigenome damage biomarkers that act as sensitive biomarkers.[39]

Carcinogen metabolism polymorphisms may alter the likelihood of carcinogen interaction with specific cells which initiates cancer activation. Single Nucleotide Polymorphism inside the genes that code for certain hormones like androgen, progesterone and also estrogens, etc have been linked to cancer risk reduction.[40] The risk of colorectal cancer is linked to excessive red meat-eating since the presence of an enzyme the N-Acetyl Transferase (NAT) having several polymorphs is associated with cancer issues.

N Acetyl Transferase is responsible for the acetylation of heterocyclic aromatic amines and can be present in well-cooked red meat. Heterocyclic aromatic amines (HAA) are formed when certain amino acids react with creatinine during high-temperature cooking of beef. Acetylation of Heterocyclic aromatic amines (HAA) can result in reactive compounds that bind to DNA and cause cancer. This activity is only possible with NAT2 rapid acetylators. Hence individuals with N Acetyl Transferase (NAT) acetylator genotype have an enhanced risk of cancer mainly in the colon region. Other cancers in postmenopausal women occurrence of breast cancer, endometrial, kidney, colon, etc.[41] Gastric cancer may be caused by specific food components such as salts and preservatives, which have been considered probable carcinogens.[42] Antioxidants that help in cancer management are electron acceptors that operate as therapeutic biologic response modifiers. Many anti-carcinogenic drugs work by acting as antioxidants by preventing DNA damage caused because of formation of reactive oxygen species. Antioxidants can easily interact with one another by sequentially recycling redox processes to neutralize Reactive Oxygen Species or free radicals.[43]

One of the significant successes is the development of dietary substances that can modify the expression of certain genes involved in the neutralization of Reactive Oxygen Species. Phytoestrogens, on the other hand, are plant-derived compounds that have a structural similarity to human estrogen. It could serve as an estrogen agonist or antagonist, competing with estrogen receptors for binding. Lignans, isoflavones, coumestans, stilbenes, flavones, and flavanones are examples of these compounds. Isoflavones are a phytoestrogen found in high amounts in soy products including tofu, soy milk, textured soy protein, and miso. Many plants contain lignans, which are the building blocks of plant cell walls. Dietary lignans can be found in a variety of foods, including vegetables, whole grains, and tea. Previous research has shown that dietary food components have a synergistic effect with anti-cancer drugs.[44,45] Previous studies on cancer prevention have found that specific dietary consumption affects major signaling pathways which get disrupted in certain malignancies. Many phytochemicals have cancer-preventing properties (more than 1000).[46] Poly Unsaturated Fatty acids with long-chain help in the prevention of cancer by prevention of growth, neurological development, and acquired and innate immunity besides influencing the severity of noncommunicable chronic degenerative diseases.[47,48,49] Colonic tumor development is suppressed by the administration of omega 3 fatty acids as proved by certain *invivo* and *invitro* researches. A variety of bioactive components present in both vegetables and fruits help to prevent cancer by speeding up the detoxification process.[50,51]

Diabetes and Nutrigenomics

Diabetes affects the human population globally with anticipation that their number will rise from 387 million to 592 million by 2035. (International Diabetes Federation, IDF).52The death of pancreatic islets by T lymphocyte infiltration causes type I diabetes (T1DM), which results in cell loss and inadequate

insulin secretion, whereas type II diabetes (T2DM), which accounts for more than 90% of diabetes cases, is the most common complicated condition. Diabetes Mellitus primarily affects persons between the ages of 40 and 59. Many various factors, such as metabolic profile, genes and food, environmental changes, and their interactions, play a major role in illness progression and pathogenesis. The impact of dietary items on gene activity was investigated utilizing omics methods, which aid in the discovery of targets such as proteins, genes, and their interactions with nutrients.[53]

It is critical to investigate nutrient-gene interactions in the etiopathogenesis of diverse metabolic disorders. By modulating signaling molecules in complex metabolic processes, these factors can regulate gene expression. A genomics study found that 65 (SNPs) are connected to the chance of having Type 2 Diabetes . With recent advances in human genome decoding and genome sequencing, testing for the detection of (SNPs) linked to Type II Diabetes has become more accessible to individuals, allowing patients to learn about their genetic predisposition to the disease's development.[54]

Cardiovascular Diseases and Nutrigenomics

World Health Organization stated that Cardiovascular diseases contribute to 17.5 million deaths in 2012. In cases of Cardio Vascular Diseases (CVD), intimal lesions arise as a result of lipid accumulation, pus cells, blood cells, fibrosis, inflammatory response, and cell death in blood arteries.[55] Nutrition is important in the treatment and prevention of cardiovascular disease. Peroxisome proliferator (PPAR), Fatty acid synthetase (FASN), lipoprotein lipase (LPL), arachidonate 5 lipoxygenase (ALOX5), apolipoprotein E (APOE), and other genes that aid in metabolism and lipid biosynthesis can all be controlled by eating a nutritious diet. Variation in the genes that code for various enzymes, hormones, and apolipoproteins can alter a person's susceptibility to cardiovascular disease.[55] Evidence-based research has reported that the arachidonate 5 lipoxygenase (ALOX5) gene, influences the synthesis of leukotriene, chemokines, and cytokines as its increased levels were found in individuals suffering from atherosclerotic lesions, indicating an increase in inflammatory cell mobilization. However, by consuming a diet rich in omega 3 polyunsaturated fatty acids, which alter eicosanoid biosynthesis, leukotriene formation is inhibited.[56] By influencing the expression of factors, polyunsaturated fatty acids (PUFA) assist in the metabolism of lipids and carbohydrates. As a result, patients who consumed these necessary fatty acids had lower levels of low-density lipoprotein (LDL) cholesterol.[57] In response to a high-fat diet, protective HDL levels are enhanced by one polymorphism (-504 cc) among the hepatic lipase gene in select ethnic groups, such as African–Americans. PUFA controls gene expression by changing membrane fluidity or by generating alternative ligands. Thus, the above explanations indicate that according to a person's genotype, dietary actions might be utilized in the management of Cardiac Dieases.[46]

Obesity and Nutrigenomics

Obesity is a nutrition-related illness that greatly increases vulnerability to degenerative diseases and is one of the primary metabolic anomalies. As a result, an individual's propensity to obesity is defined by the energy balance regulation in genetically set patterns.[24] According to research, roughly 80% of the differences in twins' Body Mass Index (BMI) are due to hereditary factors.[58] Genes with polymorphic characteristics involved in encoding peripheral and central factors associated with energy expenditure and intake have been published besides this several peripheral signaling peptides such cholecystokinin, leptin, insulin, and ghrelin, as well as some related encoding taste receptors, influence food intake control due to polymorphisms in the genes and have a direct association with weight management. Genes involved in modulators of energy expenditure encoding have polymorphic characteristics, and are deeply involved in the regulation of adipocyte development and differentiation and also protein uncoupling. Melanocortin pathway components, hypothalamic neuropeptide Y, and other key neuropeptides make up a polymorphic central regulator of energy intake.[24]

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 compounds suppress the expression of certain genes. Green tea contains -tocopherol,

which reduces inflammatory activities as it is an antioxidant and is quite effective in protecting obese research suggests that this component may be useful in the treatment of obesity.[59]

Functional Foods and Nutrigenomics

The concept of functional foods first emerged in Japan in the 1980s, 1999 it was explained as a food source containing certain nutrients or non-nutrient having a specific impact on certain body functions of an individual and also ensuring proper supply of nutrients thus facilitating functional and nutritional benefits60. Natural foods rich in minerals, vitamins, fatty acids, phytosterol, and antioxidants are categorized as functional foods. In the present scenario, the food industry focuses on the development of functional foods targeting calorie reduction, reducing glycaemic index, and lower in fat content.[61]

Application of Nutrigenomics in the Production of Genetically Modified Foods

- Knowledge of Nutrigenomics can be applied for development of Functional Foods. Transgenic organism or foods which are beneficial for general wellbeing as well as in certain diseased conditions can be produced commercially by altering certain genes.[62]
- Beginning of post genomic age is related to production of functional meals supporting specific health benefit. Such health claims are benefitted by sophisticated Technologies like DNA chip technology applied in integrated form on omics platform, striving to provide society with nutritionally rich and diversified balance diet.[63]
- Application of cutting edge technologies like genomics, proteomics and metabolomics for improving crop production and enhancing functional food sources in market can further help in lowering unflavourful chemicals like phytic acid, acrylamide amino acids there by improving nutrition further.[64,65,66,67]

Future Trends and Challenges in Nutrigenomics

Nutrigenetics and nutrigenomics are becoming increasingly important particularly in research based on health and nutritional outcomes, by using 'omic' technologies as well as biomarkers one can comprehensively study the outcomes on the nutritional status. Although these technologies are in a very preliminary stage however others are quite established with proven results. Now it is evident that information related to the genotype or species, of the individual, has a great influence on dietary requirements. Therefore, dietary recommendations based on genotypes of individuals are practical only in certain cases wherein the genotypic effect outweighs the other determinants like the nutritional and health status of the individual. Nutrigenomics evidence-based works are generating a flood of new information, and it will become clearer as time goes on which genetic characteristics should be given special consideration while working out dietary recommendations for main subgroups based on genetic information. Research has provided effective evidence highlighting vast variation in responses to dietary changes within a common genetic subgroup too. Hence it can be considered essential in the case of personalized nutrition targeting health benefits for an individual one needs to collaborate advice based on nutrigenetics with 'omic' biomarkers.[68]

Therefore, an evidence-based approach is essential before implementing nutrigenetic/ nutrigenomic science and scrutinizing it appropriately for success. Dieticians and medical personnel should enrich their knowledge in the discussed field via appropriate sources so that practical application of their ideas is ensured and their exploitation is avoided since nutrition has an integrated approach with preventive medicine. Everyone reacts to food differently therefore it is recommended to adopt targeted intervention strategies to develop an understanding with deep insight of how the phenotype is affected by nutrient gene interactions. Furthermore, this information is quite helpful in developing a personalized approach targeting nutrition mainly towards disease prevention and devising therapy. The challenges of unraveling the nutrigenomic-disease interrelationship will be difficult, but the public health ramifications are tremendous. It's crucial to assess whether personalized individual advice can promote public health.

The use of nutrigenetics/nutrigenomics targeting public health advice comes with its own set of dangers. Since it targets the study of health and disease association with genes thereby diluting broad health-related messages. However,

it is expected that in long run such scientific fields can assist in optimizing nutrition with a focus on the commendable impact on health, and wellness as well as slowing the process of age retardation.[69]

By revealing novel nutrient-gene interactions, supporting new diagnostic tests for negative diet responses, and differentiating and managing populations with specialized nutrient requirements, nutrigenomic applications will benefit human health in both the short and long term.

Biomarkers for societal well-being, early biomarkers for disease predisposition, and bioactive food components are all predicted to be delivered via nutrigenomics in the future. Furthermore, to reap the benefits of these bidirectional technologies, both developing and developed countries should establish a robust network to share scientific and technological experience in nutrigenomics through the implementation and integration of new post-genomic technologies.[70] The most pressing issue in nutrigenomics is a large amount of gathered data and generated information, such as genotype characterization, diet-gene interactions, and the reusability of biobank data. One of the most critical considerations about nutrigenomics is how individuals will approach nutrigenetic tests and the lifestyle and nutritional advice that comes with them. To examine the nutrigenomic product, multiple regulatory frameworks and ethical criteria are required. In terms of basic nutrigenomics research and its commercial and therapeutic applications, international experts highlighted five areas. (i) Nutrigenomics contributes to the development of health claims. (ii) nutrigenomics products (iii) nutrigenomic information supervision (iv) fair access to nutrigenomics (v) nutrigenomics service delivery techniques As a result, it is critical to increase the intensity of discourse to better comprehend and manage all of the aforementioned issues.[71]

The goal of nutrigenomics is to prevent chronic diseases from starting and progressing. Its knowledge is useful for health promotion, chronic illness prevention, and treatment. Nutrigenomics is beneficial to all healthy people, not only patients but also those at risk. The globe is confronting an increasing epidemic of certain chronic non-communicable degenerative diseases in terms of health. For the treatment or prevention of these disorders, we need to focus more on nutritional studies. However, this branch of science is still in the emerging phase as we need sufficient evidence for validation of results attained for benefits related to health as well as prevention of diseases. It is critical to identify volunteers for nutritional and epidemiological studies who are representative of entire communities. The selection of research volunteers can be a difficult undertaking that poses both scientific and ethical concerns. To manage information on nutrigenomics, benefits of health claims and information on nutrigenomics products also deliver methods associated with related services, and equitable access to the public as these are important aspects to be fulfilled while conducting nutrition research.[72] Nutrigenomics helps in the detection of vulnerability to disease resulting from low penetrance polymorphisms, nutritional genetics will almost certainly always be a probabilistic science. The ethical and regulatory difficulties related to dietary genetics are partly relevant to the nature and strength of the science, therefore researchers should be cautious. As research reveals mysteries or answers questions about the individual brain so there must be an ethical as well as regulatory assessment of science. Thus it is important to create awareness in the public, tactics prevention, and development of insight related to possible hazards and associated advantages in the ever-growing field of science loaded with the latest opportunities and limitations in the field of nutrigenomics along with its commercial application. Thus this rapidly evolving branch of nutritional genetics is of great promise for identifying susceptibilities related to disease occurrence which can be considered a mandatory effort for health promotion as well as prevention. However there is still a lack of proper pieces of evidence required for validation of results considering the global health scenario as the entire globe is facing the growing epidemic of certain noncommunicable chronic diseases, hence efforts should be directed towards nutrition research not only for curing but also for prevention of these diseases.

Conclusion

Nutrigenetics examines how an individual's gene setup interacts with specific dietary nutrients. This branch looks at the impact of genetic diversity on the diet-disease interaction or nutritional

recommendations. However, while their immediate objectives are distinct, the long-term goal of nutritional research is to improve an individual's health and help in the prevention of disease. Vast information has been revealed by gene-specific dietary information and this has assisted physicians in devising medicinal approaches to the treatment of complicated diseases degenerative in nature. In the future, this information can be applied to a wide population, but feasibility is to be confirmed, but nutrigenomics knowledge is predicted to allow for more tailored interventions shortly. The scientific community must work together to adhere to the principles set forth for nutritional research in terms of experimental design, analysis, and data management. This technique will aid in the creation of a meaningful database useful for clinicians and practitioners. Thus with help of research involving understanding nutrigenomics better dietary regimes might be formulated and novel treatments for certain chronic diseases can be worked out. By applying approaches including single nucleotide polymorphisms (SNPs), microarrays, and genomics for improving nutrient intake thereby promoting overall health and wellbeing. Thus amalgamation of both these disciplines ie Nutrition and genetics helps in investigating how genetic variation impacts diet and disease thus helps in devising long-term goals for improving health and prevention of disease. In the future, this knowledge needs to be applied and used for a larger population with proper planning and targeted interventions. To ensure success collective efforts of the entire scientific community are essential and this will help us in the creation of a strong database validated with strong evidence helpful for Dieticians as well as Clinicians.

Acknowledgements

The author would like to acknowledge IIS deemed to be a University for providing an appropriate environment along with other necessary facilities to facilitate the staff and students for attaining research endeavours.

Funding

Nil

Conflict of Interest

Nil

References

1. Subbiah MT. Nutrigenetics and nutraceuticals: the next wave riding on personalized medicine. *Transl Res*. 2007;149(2): 55–6.
2. Bull C, Fenech M. Genome health nutrigenomics and nutrigenetics: nutritional requirements for chromosomal stability and telomere maintenance at the individual level. Proc *Nutr Soc.* 2008;67(2):146-56.
3. Roberts MA, Mutch DM, German JB. Genomics: food and nutrition. *Curr Opin Biotechnoly.* 2001;2(5):516–522.
4. Fenech M, El-Sohemy A, Cahill L, Lynnette Robin Ferguson. Nutrigenetics and Nutrigenomics: Viewpoints on the Current Status and Applications in Nutrition Research and Practice. *J Nutr Nutr.* 2011; 4(2):69–89.
5. Mariman ECM. Nutrigenomics and nutrigenetics: the 'omics' revolution in nutritional science. *Biotechnol Appl Biochem.* 2006;44(3):119.
6. Ordovas JM, Mooser V. Nutrigenomics, and nutrigenetics. Curr Opin Lipidol. 2004; 15(2):101–108.
7. German JB. Genetic dietetic: nutrigenomics ad the future of dietetic practice. *J Am Diet Assoc*. 2005; 530–1.
8. Miggiano GA, De Sanctis. Nutritional genomics: toward a personalized diet US National Library of Medicine, National institutes of health. *Clin Ter*. 2006; 157(4):355–61.
9. International Human Genome Sequencing Consortium. Finishing the euchromatic sequence of the human genome. *Nature.* 2004; 431(7011):931– 945.
10. Murgia C, Adamski MM. Translation of Nutritional Genomics into Nutrition Practice: The Next Step. Nutrients. 2017; 9(4):366.
11. Chadwick R. Proceedings of the Nutrition Society. 2004; 63:161-166.

12. Muller M & Kersten S. Nature Reviews Genetics. 2003; 4:315-322.
13. David M. Mutch, Walter Wahli, Gary Williamson. Nutrigenomics and nutrigenetics: the emerging faces of Nutrition. *FASEB J*. 2005; 19(12): 1602-16.
14. El-Sohemy A. The Science of Nutrigenomics. Health Law Review. 2008; 16 (3): 5-8.
15. Kaput J, Raymond LR . Nutritional genomics: the next frontier in the Post genomic era. *Physiol Genomics.* 2004; 16: 167-77.
16. Ames BN, Elson-Schwab I, Silver EA . High-dose vitamin therapy stimulates variant enzymes with decreased coenzyme binding affinity (increased Km): relevance to genetic disease and polymorphisms. *Am J Clin Nutr*. 2002; 75(4): 616-58.
17. Palou A. From nutrigenomics to personalized nutrition. *Genes Nutr.* 2007; 2(1):5-7.
18. Pavlidis C, Patrinos GP, Katsila T. Nutrigenomics: A controversy. *Appl Transl Genomics.* 2015; 4:50–53.
19. de Graaf AA, Freidig A P, De Roos B, Jamshidi N, Heinemann M, Rullmann JAC, Hall KD, Adiels M and Ommen BV. Nutritional systems biology modeling: from molecular mechanisms to physiology. *PLoS Comput Biol.* 2009; 5:e1000554.
20. Ordovas JM, Corella D. Nutritional genomics. Annu Rev Genomics Hum Genet. 2004; 5:71–118.
21. Ordovas JM. Gender is a significant factor in the cross-talk between genes, environment, and health. *Gend Med.* 2007; 4(suppl B): S111–S122.
22. United States Department of Agriculture: Steps to a healthier you. www.mypyramid.gov.
23. Breitbart RE, Andreadis A, Nadal-Ginard B. Alternative Splicing: A Ubiquitous Mechanism for the Generation of Multiple Protein Isoforms from Single Genes. *Annu Rev Biochem.* 1987; 56(1):467–495.
24. Loktionov A. Common gene polymorphisms and nutrition: emerging links with the pathogenesis of multifactorial chronic diseases. J Nutr Biochem. 2003; 14:426–51.
25. Trujillo E, Davis C, Milner J. Nutrigenomics, proteomics, metabolomics, and the practice of dietetics. J *Am Diet Assoc.* 2006; 1 06:403–413.
26. Sales N M R, Pelegrini P B and Goersch M C. Nutrigenomics: Definitions and Advances of This New Science. Bio information. 2014; 1(4), 44-49.
27. Shamim N, Gupta A, Paul V, and Vida E. Nutritional genomics: A review. The Pharma Innovation; 6(4, Part A). 2017; 17-20.
28. Jirtle RL, Skinner MK: Environmental epigenomics and disease susceptibility. *Nat Rev Genet.* 2007 ; 8:253–262.
29. Paoloni-Giacobino A, Grimble R and Pichard C . *Genetics and nutrition.Clin Nutr.* 2003; 22(5): 429-35.
30. Ferguson LR. Nutrigenomics: integrating genomics approaches into nutrition research. *Mol Diag Ther.* 2006; 10(2):101.
31. CorthésyTheulaz I, den Dunnen JT, Ferré P, Geurts JMW, Müller M, van Belzen N, van Ommen B. Nutrigenomics: the impact of biomics technology on nutrition research. *Ann Nutr Metab.* 2005; 49:355-65.
32. Felty Q and Roy D. Estrogen, mitochondria, and growth of cancer and noncancer cells. Journal of carcinogenesis. 2005; 4(1):1-1.
33. Waris G and Achsah H. Reactive oxygen species: Role in the development of cancer and various chronic conditions. *Journal of Carcinogenesis.* 2006; 5(1): 14-17.
34. Droge W. Free radicals in the physiological control of cell function. Physiological Reviews. 2002;82(1): 47-95.
35. Zhou S, Kremling K A, Bandillo N, Richter A, Zhang Y K and Ahern, K. R. Metabolome-scale Genome-wide Association Studies Reveal Chemical Diversity and Genetic Control of maize Specialized Metabolites. *Plant Cell.* 2019; 31 (5): 937–955. doi:10.1105/tpc.18.00772.
36. Oster T and Pillot T. Docosahexaenoic acid and synaptic protection in Alzheimer's disease mice. *Biochim Biophys Acta.* 2010;1801:791–798.
37. Suchy J, Chan A, and Shea TB. Dietary supplementation with a combination of alpha-lipoic acid, acetyl-L-carnitine, glycerophosphocholine, docosahexaenoic acid, and phosphatidylserine reduces oxidative damage to the murine brain and improves cognitive performance. *Nutr Res.* 2009; 29:70–74.

38. Zhao H, Li Q, Zhang Z, Pei X, and Wang J and Li Y. Long-term ginsenoside consumption prevent memory loss in aged SAMP8 mice by decreasing oxidative stress and up-regulating the plasticity-related proteins in the hippocampus. *Brain Res.* 2009; 1256:111–122.
39. Vauzour D, Corona G and Spencer JP. Caffeic acid, tyrosol, and p-coumaric acid are potent inhibitors of 5-S-cysteinyldopamine-induced neurotoxicity. *Arch Biochem Biophys*. 2010; 501:106–111.
40. Ng PC, Murray SS, Levy S and Venter JC. An agenda for personalized medicine. *Nature.* 2009; 461:724–726.
41. Cheng L, Zheng W, Li M, Huang, J, Bao S, Xu, Q. Citrus Fruits Are Rich in Flavonoids for Immunoregulation and Potential Targeting ACE. *Preprints*; 2020020313.2020.
42. Bouwman LI. Personalized nutrition advice, an everyday-life perspective; thesis, Wageningen University, ISBN 978–90–8585–363–3. 2008.
43. Drisko J A, Chapman J, and Hunter VJ. The use of antioxidant therapies during chemotherapy. *Gynecologic oncology.* 2003; 88(3):434-439.
44. Singh N, Sahu D K, Chowdhry R, Mishra A, Goel M M, Faheem M, and Kant R. IsoSeq analysis and functional annotation of the infratentorial ependymoma tumor tissue on PacBio RSII platform. *Meta gene*. 2016; 7:70-75.
45. Kaushik S, Shyam H, Sharma R and Balapure A K. Genistein synergize centchroman action in human breast cancer cells. *Indian journal of pharmacology.* 2016; 48(6):637.
46. Tai ES and Tan CE. Genes, diet, and serum lipid concentrations: lessons from ethnically diverse populations and their relevance to coronary heart disease in Asia. *Curr Opin Lipidol.* 2004;15:5–12.
47. Mak KH, Chia KS, Kark JD, Chua T, Tan C, Foong BH, Lim YL and Chew SK, Ethnic differences in acute myocardial infarction in Singapore. *Eur Heart J.* 2003; 24:151–160. https://doi.org/10.1016/S0195-668X(02)00423-2
48. Tan CE, Emmanuel SC, Tan BY and Jacob E. Prevalence of diabetes and ethnic differences in cardiovascular risk factors. The 1992 Singapore National Health Survey. Diabetes Care. 1999; 22:241–247.
49. Cutter J, Tan BY, and Chew SK. Levels of cardiovascular disease risk factors in Singapore following a national intervention program. *Bull World Health Organ.* 2001; 79:908–915.
50. Hughes K. Trends in mortality from ischaemic heart disease in Singapore, 1959 to 1983. *Int J Epidemiol.* 1986;15:44–50.
51. Khoo KL, Tan H, Liew YM, Deslypere JP, and Janus E. Lipids and coronary heart disease in Asia. *Atherosclerosis.* 2003;169:1–10.
52. Aguirreiree F, Brown A, Cho N H, Dahlquist G, Dodd S, Dunning T and Scott, C. IDF diabetes atlas. 2013.
53. Ovesná J, Slabý O, Toussaint O, Kodíček M, Maršík P, Pouchová and Vaněk T. High throughput 'omics' approaches to assessing the effects of phytochemicals in human health studies. *British Journal of Nutrition.* 2008; 99(E-S1), ES127-ES134.
54. Vorderstrasse A A, Cho A, Voils C I, Orlando L A and Ginsburg G S. Clinical utility of genetic risk testing in primary care: the example of Type 2 diabetes. *Personalized medicine,* 2013;10(6):549-563.
55. Pagidipati N J and Gaziano TA . Estimating deaths from cardiovascular disease: a review of global methodologies of mortality measurement. *Circulation.* 2013. 27(6):749-756.
56. Ferretti A, Nelson G J, Schmidt, P C, Kelley D S, Bartolini G, and Flanagan V P. Increased dietary arachidonic acid enhances the synthesis of vasoactive eicosanoids in humans. Lipids. 1997; 32(4):435-439.
57. Matthew J, McQueen, Hawh=ken S, Wang X, Ounpuu S, Sniderman A, Probstfield J, Steyn K, Sanderson JE, Mohammad H, Volkova E, Kazmi K and Yusuf S . Lipids, lipoproteins, and apolipoproteins as risk markers of myocardial infarction in 52 countries (the INTERHEART study): a case-control study. *The Lancet.* 2008; 372(9634): 224-233. https://doi.org/10.1016/S0140-6736(08)61076-4
58. Phillips C M. Nutrigenetics and metabolic disease: current status and implications for personalized nutrition. *Nutrients.* 2013; 5(1):32-57.

59. Shamim N, Gupta A, Paul V, and Vida E. Nutritional genomics: A review. The Pharma Innovation. 2017;6(4):17-20.
60. Ashwell M. Conceptos sobre los alimentos funcionales. International Life Science Institute (ILSI). ILSI Press. Washington DC. 2004;48.
61. García-Casal MN. La alimentación del futuro: Nuevas tecnologías y su importancia en la nutrición de la poblacion. *Anales Venezolanos de Nutricion.* 2007; 20(2):108–114.
62. Vidal DR. Transgenicos, nutrigenetica y nutrigenomica en alimentacion. Tecnología i Ciencia dels Aliments. 2009; 11(1):10–12.
63. Kaput J. Nutrigenomics research for personalized nutrition and medicine. *Current opinion in biotechnology.* 2008; 19(2):110-120.
64. Ye X, Al-Babili S, Klöti A, Zhang J, Lucca P, Beyer P and Potrykus I. Engineering the Provitamin A (-Carotene) Biosynthetic Pathway into (Carotenoid-free) Rice Endosperm. Science, 2000; 287 (5451):303–305. https://doi.org:10.1126/science.287.5451.303 Gil-Humanes J, Pistón F, Altamirano-Fortoul R, Real A, Comino I, Sousa C, Rosell CM, and Barro F. Reduced-gliadin Wheat Bread: an Alternative to the Gluten-free Diet for Consumers Suffering Gluten-Related Pathologies.; PLoS ONE, 2014; 9 (3): e90898. https://doi.org:10.1371/journal.pone.0090898
65. Mugode L, Ha B, Kaunda A, Sikombe T, Phiri S, Mutale R, Davis C, Tanumihardjo S and DeMoura FF . Carotenoid Retention of Biofortified Provitamin A maize (Zea mays L.) after Zambian Traditional Methods of Milling, Cooking, and Storage. *J. Agric. Food Chem.* 2014; 62 (27):6317–6325. https://doi.org:10.1021/jf501233f
66. Trijatmiko K R, Dueñas C, Tsakirpaloglou N, Torrizo L, Arines FM, Adeva C, Balindong J, Oliva N, Sapasap MV, Borrero J, Rey J, Francisco P, Nelson A, Nakanishi H, Lombi E, Tako E, Glahn RP, Stangoulis J, Chadha-Mohanty P, Johnson AAT, Tohme J, Barry G and Slamet- Loedin IH. Biofortified Indica rice Attains Iron and Zinc Nutrition Dietary Targets in the Field. *Sci. Rep.* 2016; 6(1): 19792–19813. https://doi.org:10.1038/srep19792.
67. Gupta E, Sharma H, Devi S and Maurya NK. Nutrigenomics in Functional Foods and Personalized Nutrition. 2020; 33(02):670-686.
68. TGG Uthpala, HN Fernand, Thibbotuwawa A, and M Jayasinghe. Importance of nutrigenomics and nutrigenetics in food Science. MOJ Food Processing & Technology. 2020; 8(3):1-6.
69. Garg R, Sharma N, and Jain SK. Nutrigenomics and Nutrigenetics: Concepts and Applications in Nutrition Research and Practice. *Acta Medica International.* 2022; 1 (2):124-130.
70. Maurya NK. Nutrigenomics in Functional Foods and Personalized Nutrition. *GEDRAG Organ Rev.* 2020; 33(2):77-85
71. Derossi A, Husain A, Caporizzi R and Severini C. Manufacturing personalized food for people uniqueness. An overview of traditional to emerging technologies. *Crit Rev Food Sci Nutr.* 2019; 11;60(7):1141–1159. https://doi.org/10.1080/10408398.2018.1559796