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Nutrigenomics: A combination of nutrition and genomics: A new concept

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Abstract

The food habits and lifestyle of people is undergoing a lot of changes and these changes are having lot of negative repercussions on the health of individuals. In order to work towards health improvisation, various techniques and concepts are emerging day by day and one such constructive concept is Nutrigenomics. The branch of nutrigenomics studies the interaction of food and its components with the genome at molecular, cellular as well as systemic level, the major goal being using diet for the prevention or treatment of disease. It studies the relationship of nutrient and genes. The effects of nutrigenomics may be useful in ensuring improved health; wellbeing and good performance and also counteracting food intolerances, allergies, increased susceptibility to chronic diseases etc. It aims at providing diet to the individuals based on their genetic makeup and hence studies the effect of nutrients on genome, proteome and metabolome. The concept of nutrigenomics brings together the disciplines of bioinformatics, nutrition, molecular biology, genomics, epidemiology, and molecular medicine. This paper includes a concise review to the emerging and innovative field of nutrigenomics and outlines a number of advantages of the same.

Keywords: Nutrition, genomics, diet, genetic makeup

1. Introduction

Food is an integral part of one's life. We relate to food in almost every aspect of life. It not only fulfils the satiety level of human needs but also serves many functions, the priority being over the nutritive value of the food that is eaten and the nutrition that a person derives after consumption of particular food stuff.

Diet is a major factor along with various other environmental factors, which has a direct implication on health and a variety of chronic diseases [1].

Since Nutrition is the first and foremost thing related to the food that we eat, therefore it becomes imperative for us to understand the concept of Nutrition. It is a science which involves several steps like uptake of food or ingestion, digestion of food, absorption and assimilation of food for the purpose of repair, growth and maintenance of the body. It is the process of nourishment or being nourished with the help of certain compounds present in foods which are called as Nutrients. These includes carbohydrates, proteins, lipids, minerals, vitamins, dietary fiber and last but not the least water. All in all, food is eaten for the purpose of nourishing the body and in turn maintaining the health.

There is a direct relationship of food with health of an individual; the food that one eats directly affects his/her health. There are both, positive as well as negative effects of the food that we consume. Malnourishment and Over nourishment are implications of food on health. Apart from these effects, certain consequences are chronic and lead to lifestyle diseases. Such consequences need to be corrected and alleviated. The emergence of such consequences is clear evidence which shows that dietary chemicals directly affect the molecular and genetic processes.

An individual is exposed to a wide and complex variety of foods during his/her lifetime and diet becomes the most important environmental factor which affects the biological system [2]. Nowadays health has been linked to the genetic makeup of an individual; therefore, people are choosing foods keeping in mind their genetic makeup and a similar concept is Nutritional genomics.

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The point that our food affects the genes can be analyzed from the fact that the food we eat is made up of a number of components which are highly complex in nature. And as discussed earlier, these components have both good as well as bad implications on our health. A number of processes which takes place in biological system of our body, work together to extract energy trapped in these complex components and help the body to utilize that energy for growth and maintenance. This might include certain things which were considered unimportant in the past but have gained value over the recent times.

One of the strong facts underlying the effect of food that we eat lies on the forefront that the food eaten does not affect each and every individual in the same way, there are individual variations which exists.

There are individual genetic differences which have been evident in the past years also. For e.g. the intake of saturated fat and cholesterol might cause certain deteriorating changes in one individual while not in the other. These are all genetic differences which exist and which shows the link between the food consumed and its effect on genes and the final outcome.

2. Definition

Genomics is the study of the genetic material i.e. the genome of an organism. When genomics is combined with the science of nutrition, it is called as Nutri genomics or Nutritional Genomics.

The relationship between nutrients and genes is studied by Nutrigenomics^[3]. It is a scientific discipline which studies the interaction between our genes and nutrition along with their expression to the lifestyle choices and how these can influence our health and wellness. Nutritional Genomics or Nutrigenomics implies Nutrition and genomics, which goes hand in hand and is affected by the other.

It is a branch of nutrition which depends on molecular tools to investigate, use and recognize the outcomes of a certain kind of a diet applied to a single or a group of individuals^[4].

Along with the emergence of functional food industry, nutrigenomics is also gaining pace to provide benefits from foods beyond the basic nutrition^[5]. The science of nutrigenomics involves the use of various advanced “omics” technologies like transcriptomics, metabolomics and proteomics to explore the consequences and effects of nutrition and nutrients on health^[6].

According to Johnson and Kaput^[7] nutrigenomics studies how molecular expression of genetic information is altered by the natural chemicals of food in each individual. Along with bioinformatics, a number of other disciplines support the process, viz., nutrition, molecular biology and genomics. Integrating all these disciplines is useful in understanding individual and population differences and similarities in gene expression, with reference to the diet consumed.

The perspective of nutrigenomics states nutritional components as signals, which can be detected by body cells and influence expression of genes and proteins and consequently production of metabolites. It aims to study how nutrition influences homeostasis and identification of genes responsible or dietary diseases^[8].

When we talk about the omics revolution in nutrition, two commonly used terms are often used i.e. Nutrigenomics and Nutri-genetics, and both these terms are often confused to be the same. But there are differences in both the concept, although both are aimed at optimizing health. Nutrigenomics, basically studies the interaction between genes and nutrients. It elucidates the requirements of various nutrients as per the

genetic code and DNA, which is needed to maintain optimal health. It is based on the interaction of diet and gene and identification of positive and negative effects of diet on health^[9].

According to Ordovas and Mooser^[10] nutrigenomics studies the interaction of food and its components with the genome at molecular, cellular as well as systemic level, the major goal being using diet for the prevention or treatment of disease.

On the other hand, Nutri-genetics focuses on studying the effect of genetic background on an individual’s diet^[9]. These effects may favor the individual such as improved health; wellbeing and good performance and some of these might be negative such as food intolerances, allergies, increased susceptibility to chronic diseases etc. It helps in facilitating disease prevention related to food, if the diet of an individual is the risk factor behind disease. Personalized health advice to individuals on the basis of nutrigenetics can prevent, delay or reduce the symptoms of chronic diseases^[11]. It works on clarifying different responses of different individuals to the same dietary component or nutrient^[12].

The concept of genomic research in nutrition can best be concluded on these 5 basic principles^[13,14].

1. The nutrients present in the food, whether micro or macro, have the ability to directly or indirectly altering the human genome by changing the gene structure and expression.
2. Under particular conditions and in certain individuals, diet is the most important factor for the development of disease (s).
3. The genetic makeup of the individual is a major factor which influences the effect of the diet on the individual. Therefore, in case of every individual the effect of diet on health and disease would be different.
4. Diet-regulated genes (and their normal, common variants) may affect the onset, incidence, progression, and/or severity of chronic diseases.
5. Prevention, healing, mitigation of chronic diseases can be taken care of with dietary intervention or personalized nutrition based on nutritional requirements, nutritional status, and genotype

3. Objective

In Nutrigenomics, nutrients are considered as potent signals that give information to a specific cell about the diet. The sensor in the cell helps in detecting the nutrient and information transfer. Certain transcription factors and many additional proteins are responsible for interpretation of information from nutrients about the dietary environment. On interaction of nutrient with the sensory system, a lot of entities are changed i.e. the expression of gene, protein and production of metabolites. These changes are in accordance with the level of nutrient that has been sensed by the sensory system. Hence, different kinds of diets exhibit varying patterns gene and protein expression as well as metabolite production. Therefore, as per nutrigenomics, these varying patterns are termed as dietary signature^[8].

Since nutrigenomics can help identify the outcome of bioactive compounds and other health foods on health. Therefore, this strategy can be explored for the development of functional foods. Hence, one of the aims of nutrigenomics is development of functional foods as per the needs of the individuals^[15].

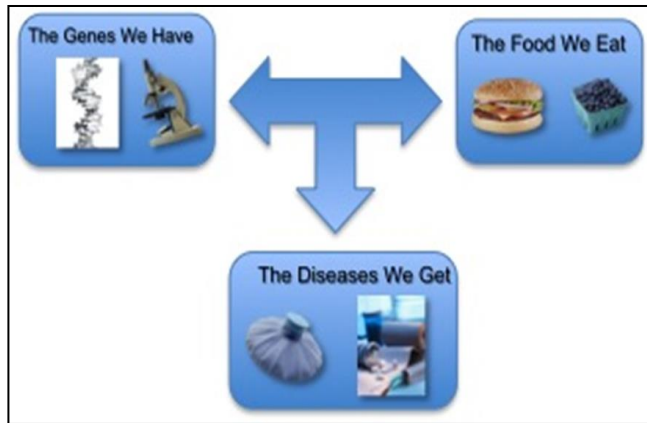


Fig 1: The inter-relationship of individual genes, diet and disease
(Courtesy: [http:// georgefebish. wordpress. com/2012 /04/](http://georgefebish.wordpress.com/2012/04/))

4. Techniques in Nutrigenomics

Nutrigenomics is the science that studies the consequences of consumption of nutrients on genome, proteome and metabolome^[16]. The genetic fingerprint of an organism is called as the genome. All nucleotide sequences are present in the genome, including structural genes, regulatory genes as well as non-coding DNA sequences. All these genes are studied in the study in terms of mapping, sequencing and analysis. The discipline of functional genomics is also called as systems biology which involves various omics technologies, such as genomics, genotyping, proteomics, and metabolomics along with bioinformatics^[2].

Transcriptomics determines patterns of gene expression in response to nutrients. The genome produces a complete set of RNA that is called as transcriptome. The expression of genes at mRNA level is studied by transcriptomics^[2]. It helps in nutrition research by exhibiting the effect of a particular nutrient or diet. It is also useful in identification of the gene, protein or metabolite that undergo changes in predisposed state of human body^[17-20].

The mRNA or gene expression is analyzed in a given sample under specific conditions, using techniques such as cDNA or oligonucleotide microarray technology². It is one of the most extensively used "omics science". The set of proteins produced by a species is called as the proteome. The proteome is very dynamic and show varying changes depending upon the type and function of the cell. The study of proteome is called as proteomics. The focus of proteomics is on three major things i.e. protein expression, function and structure²¹. This technique involves characterization of all proteins in a biological sample, along with their abundance, distribution, modifications that proteins undergo after translation, their functions and their interaction with other biological molecules^[2].

The technologies that are mainly used for proteomics are two-dimensional gel electrophoresis and specialized mass spectrophotometry techniques, used for separation of proteins in a complex mixture and identification of the proteins, respectively^[21, 25].

Metabolome can be defined as the group of metabolites synthesized by a biological system. Apart from DNA, RNA or proteins, all other substances or components present in a sample are measured by metabolomics^[26, 27, 23]. The methods of metabolomics analysis are based on Nuclear Magnetic Resonance (NMR) spectroscopy and Mass Spectrometry²⁸. In the field of nutrition, metabolomics helps in studying the metabolic arrangements and instabilities that interfere with the diet or cause disturbances^[29, 19].

5. Advantages

Nutrigenomics has its various applications in the field of health. The advancements in the field of Nutrigenomics would lead to the following features.

5.1. Improved Health

The greatest benefit which is expected to flow from the river of Nutrigenomics is improved health and consequent improvement in the quality of life. This can be achieved through personalized dietary advice, customized dietary guidelines, improved dietary habits and the development of healthier foods. But the use of a genetically customized diet as a part of nutrigenomics does not ensure cent percent prevention or cure of a particular disease like an antibiotic effect on a bacterium, whereas this approach involves adjustments to diet over a longer period of time which will probably reduce the risk of a number of disease and enable people to maintain optimal health.

5.2. Dietary advice customized to the individual

Research based on genes, diet and subsequent health outcomes is expected to lead to improved dietary advice customized as per the individual's genetic makeup. Associations between certain foods and a rise or fall in susceptibility to disease can be seen from a number of observational studies which have been made. Such studies reflect how studies based on nutrient gene interaction can prove beneficial to each and every individual, since there is genetic variation which exists amongst individuals. For example, Moderate alcohol consumption is believed to reduce the risk of heart disease but as per genetic studies people with ApoE4 gene polymorphism, alcohol consumption can raise the level of bad cholesterol leading to an increase on the risk of heart disease. Thus, to decrease the risk of bad cholesterol, such people should be encouraged to be cautious about alcohol consumption. With individual genetic profiling, it is possible to engage in an intelligent nutrition advice which will precisely be tailored keeping in mind the individual.

5.3. Improvisation in the Diet

A major task of a nutritionist or a registered dietician or allied health practitioner is to modify the diet of their clients to bring about the state of health and one of the greatest challenges that they face is to get people to modify their behaviors to improve their health. Following the advice or not really depends on person to person and there is no evidence that providing information about health-related genetic risks can motivate people to modify their behavior in a better way than if they receive non-genetic information. But nowadays, people believe that genetic testing is required and would be acceptable if it can be used to predict future illnesses. Therefore, nutritional advice if tailored as per the individual would be more acceptable and would have more reason to believe that it will work.

5.4. Development of Health foods

People are becoming more and more aware about the nutrition and are predisposing themselves to a no. of health foods available in the market. They are not only looking for attaining basic nutrition through the food that they consume but are predisposing themselves to a number of health foods which are available in the market. Since Nutri genomics aims at scientific understanding of the effects of nutrition at molecular level, therefore there will be an increased advancement in the development and acceptability of health

foods by the general masses. The so-called term “Health foods” includes functional foods, Nutra ceuticals and Medical or Medicinal foods. Functional foods include foods that are meant to provide a specific health benefit or foods having a health promoting effect beyond basic nutrition. Nutra ceuical is a substance which has been isolated from food and has proven health benefits along with prevention of chronic diseases whereas a Medicinal food is designed for dietary management of a disease or condition that is closely linked to specific nutritional requirements. Nutri genomics has led to increased awareness amongst people regarding their health and dietary needs and a natural predisposition to such foods.

5.5. Reducing Health Disparities

Nutri genomics can play a role in reducing health disparities between social groups. Some medicinally important information can be derived using Nutri genomics, including susceptibility to certain diseases. Some populations can have disproportionately high incidences of certain chronic diseases such diabetes, asthma, cardiovascular disease, and certain types of cancers. For eg, African- American men are found to have a 60% higher risk of developing prostate cancer and are two to three times more likely to die from it than Caucasian men. A number of factors are thought to be responsible for such disparities which include the relationship between diet and genetics. Genomics can be used to mark the genetic differences between the groups and the information can be used to reduce health disparities through community outreach programs etc. For e.g. the programs can be used to educate the people about the relationship of diet and genetic makeup and convincing the people to change their eating habits and attain optimal health.

5.6. Health Care Savings

The advancements in nutritional genomics can lead to cost savings for consumers, employers, government and third-party payers such as insurance companies through the prevention and delay of disease onset. Since, it has been moving towards population-based nutrition guidelines or food guidelines, therefore it will lead to reduction in mortality and morbidity and the related expenditure on health care. Another thing may be to find bioactive components of food matched with individual genotypes that could be used in the treatment instead of more expensive drugs.

Apart from the above-mentioned advantages posed by the field of Nutrigenomics, there are many others which may be explored since the field itself is still in its infancy stage and is growing day by day^[3].

6. Conclusion

The present article reviews a new concept which takes into account nutrition and genomics. The interaction of nutrients and their effect on genes can lead to improved health, improved diet as dietary advice can be customized to individual patients etc. Since each and every individual is genetically different from each other, therefore this concept can be helpful in combating various health problems by simply studying the genetic makeup and prescribing diet which will further reduce health disparities amongst people.

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