Indian Journal of Agriculture Business
Volume 2 Number 1, January - June 2016

Review Article

Neutrigenomics: A Novel Tools for Livestock and Poultry Health, Production & Nutrition

D.N. Singh*, Y. Singh*, Ajay Kumar*, Mamta*, A. Bhattacharyya, P.K. Shukla*****

Abstract

Nutrigenomics is a branch of nutritional genomics and is the study of the effects of foods and food constituents on gene expression. involve scientific understanding of human or animal genomic/genetic contributions and responses to diet/feed. The nutrigenomics considers how things in diet influence individuals genome, and how this interaction modifies phenotype, i.e., how diet alters biological systems to promote either health or disease. Nutrigenetics, on the other hand, aims to figure out how any one of us is genetically programmed to respond in a particular way to a given dietary nutrient. Application of nutrigenomics could help enhance our understanding of how nutrition influences various biological pathways and homeostatic control; how this regulation is disturbed in the early phase of diet-related/deficiency diseases and to what extent individual genetic makeup contribute to such diseases. Numerous studies in humans, animals, and cell cultures have demonstrated that macronutrients, micronutrients and naturally occurring bioreactive chemicals regulate gene expression in diverse ways. Although relatively new technologies, the various genomics applications searching for new biomarkers already have found their way to many nutritional applications. Nutrigenomics can be used to identify the specific markers to manipulate gene expression through use of nutrients or their combinations so as to improve productive as well as overall animal performance. Nutrigeonmics will be a path breaking tool through identification of pathways and candidate genes responsible for dietary induced diseases and ultimately reduction in production losses due to these diseases in animals.

Keywords: Broiler; Genome; Metabolome; Markers; Nutrigenomics.

Author Affiliation

*Assistant Professor, Department of LPM,
**Assistant Professor,
***Professor & Head,
Department of Poultry Science, College of Veterinary Science & Animal Husbandry, U.P. Pandit Deen Dayal Upadhayaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan (DUVASU), Mathura-281001.

Reprint Request

D.N. Singh, Assistant Professor, Department of LPM, College of Veterinary Science & Animal Husbandry, U.P. Pandit Deen Dayal Upadhayaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan (DUVASU), Mathura-281001.
E-mail:
drdeep25@gmail.com

Introduction

Over the last decade, advances in the biochemical technologies available for examining functional genomics have provided a number of new molecular tools for evaluating responses to nutritional strategies. These tools are largely based on an understanding of the expression and control of specific genes and gene products and have lead to the development of the sciences associated with nutrigenomics. Bioactive food compounds can interact with genes affecting transcription factors, protein expression and metabolite production. The study of howgenes and gene products interact with dietary chemicals to alter phenotype and conversely, howgenes and their products metabolize nutrients is called nutritional genomics or "nutrigenomics" (Kaput *et al., 2005*).

Nutrigenomics is the study of gene expression or metabolic pathway depending on different food

material. In recent year, nutrigenomics has gained special attention due to its great potentiality for treating chronic disease. In last few decades, it is established that proper nutrition or diet can fight against several diseases. Nutrition genomics or nutrigenomics is the study to understand the nutritional effect on gene expression. In order to explore the importance of diet and diet formulation, it is necessary to understand the physiological, biochemical and metabolic pathways when observing the responses of organisms towards dietary components. The interaction between human gene and environmental factors that cause several human diseases was first investigated in USA (Amin *et al., 2012*). Nowadays, advancement in molecular biology techniques provides us the opportunity to study the interaction between diets, metabolic pathway and gene expression. It is now well established that dietary requirement varies from one individual to another and thus random diet can cause different health related problem such as, body weight, blood pressure, blood sugar, etc. In a detail study Huang *et al*. 2011 stated that "The consumption of nuts, a diet high in carbohydrates and protein, green tea and red wine as well as the supplementation with policosanol and red yeast rice extract can be considered for improvement of the lipid profile, while the supplements of guggulipid, garlic, chromium, vitamin C, magnesium-pyridoxal-phosphate-glutamate, tocotrienols and absorbitol cannot be recommended". Whereas, in an another investigation demonstrated the correlation between diet and prostate cancer. There are several examples of nutrigenomics such as, lactose intolerance symptom which is characterized by insufficient production of lactase enzyme due to genetic variability in lactase gene (Swallow, 2003). People with lactose intolerance symptom are recommended for lactose free diet for better health. Phenylketonuria is an another classical example of nutrigenomics which is directly related to metabolic pathway disorder. Several research groups are engaged in seeking to understand the relationship between dietary/nutritional factors and the expression of genes, metabolic and physiological changes in the body. This research will give us a better understanding of homeostasis in the body, the control and expression of genes and also the metabolic pathways involved in it. Not only human, nutrigenomics study is also important in different other sectors like poultry farm and pig meat industries. In recent year, the demand of chicken and pork is increasing rapidly. Feed efficiency is an important factor in these industries which can be achieved through nutrigenomics research. Till date this area is not so explore. A greater understanding of these mechanisms will lead us to sustainable fisheries more production and other aquaculture activities.

The nutrients and other components of food serve as the key factor in controlling gene expression and transcription (Sales *et al*., 2014). It is not an approach to the basic nutrition provided by food but a rather wide area beyond it. It is already proved that pattern of gene expression varies from one individual to other due to single nucleotide polymorphism or SNPs. The types of food and its consumption quantity are thus very important for health and development of the body. Several research on nutrigenomics concluded that food with bioactive compounds are beneficial for health. Nutrigenomics studies gives opportunities for fundamentally new approaches to nutritional research that enables global study of gene expression and its effects. In this present review, we have documented the importance of nutrigenomics in animal health and diet related gene expression.

The nutritional genomic area includes two parts, nutrigenomics that is the study of interaction between dietary components and the genome and the regulating changes in proteins and other metabolism another one is nutrigenetics that identify the response to dietary components with regard to genetic differences. The new technologies like, genomics and proteomics.

Nutrient Gene Interaction

Genes are turned on and off according to metabolic signals that nucleus receives from internal factors, e.g. hormones, and external factors like nutrients, which are among the most influential of environmental stimuli. Numerous dietary components can alter genetic events, and thereby influence health. In addition to the essential nutrients, such as carbohydrates, amino acids, fatty acids, calcium, zinc, selenium, and vitamin A, C and E, there is a variety of nonessential bioactive components that seem to significantly influence health. These essential and nonessential bioactive food components are known to modify a number of cellular processes associated with health and disease prevention, including carcinogen metabolism, hormonal balance, cell signaling, cell cycle control, apoptosis, and angiogenesis. Often bioactive food components will modify several processes simultaneously. The complex mixture of natural substances that supplies both energy and building blocks to develop and sustain organism nutrients has variety of biological activity like antioxidants

(act as a free radical scavengers), nutritional hormone (potent signaling molecules) and phytochemicals (modulator for animal health and production). The essential nutrients imbalance of macronutrients in sub optimal level or even toxic concentration of certain feeds may cause many diseases and disorders.

Gene Expression Profiling

Microarray technology is a powerful tool f or the global evaluation of gene expression profiles in tissues and for understanding many of the factors controlling the regulation of gene transcription. This technique not only provides a considerable amount of information on markers and a predictive factor that may be potentially characterize a specific clinical picture, but also promisesnew applications for therapy. The use microarray evaluating nutritional strategies and nutrition effect by individual gene marker have variable response in individual animal receiving same level of feeds and also possible to compare gene expression patterns in group of animals. It is also to identify specific similarities and differences in nutrient effects across a number of genes.

Nutrigenomics in Animal Sector

In recent year, nutrition research gains a special attention due to its vast application in several branches of science. It is already proved that not only environmental cues but several other factors are associated with animal health. Nutritional genomics is a recent off-shoot of this genetic revolution. Recent research indicated that bioactive material present in diet alone act as a transcriptional factor or interact with transcription factor and regulate the expression of metabolic genes (Sales *et al.*, 2014).

Advantages of Nutrigenomics in Ruminants

- Improves ruminant health
- Improves production of milk fat
- Improve fertility and reproductive performance

Nutrigenomics in Poultry Birds

Maysa *et al.,* (2009) reported that the effect of organic selenium (sel-plex™) on productive, reproductive and physiological traits of bandarah local strain. Fertility and hatchability percentages were significantly increased in treated groups but hatched chicks weight was increase supplementation in the diets had improved the productive, reproductive and physiological traits in females and males of Bandarah local strain. Live body weight of females was significantly increasedwith increase of hens age, but no significant effect on feed consumption as the age of birds increased. Egg production percentage, egg weight, egg quality and selenium content in yolk and albumen were significantly increased for hens fed SelPlex™ supplementation Semen ejaculate volume, advanced motility (%), alive sperm (%) and spermconcentration were significantly increased by Sel-Plex™ supplementation in cock's diet. Selenium is an essential component of at least 25 selenoproteins involved number of physiological function, including reproduction and fertility of hens. Supplementation of organic and inorganic selenium in hens revealed that energy production and protein translation was greater in oviduct when organic selenium added to feed. This is not observed in the supplementation of inorganic selenium (Brennan *et al.,* 2011). Improving broiler breeder by optimizing nutrition with specific feed rations is possible.

Conclusion

Traditional research related to animal nutrition is mainly deals with either deficiency or excess of the particular nutrient which leads to ill health as well as decreased animal production. But genomic revolution has propelled the development of several new technologies that can be applied in nutritional sciences. New techniques like genomic, proteomic, metabolomic, and bioinformatics are now making their ways to solve the intervening puzzle between nutrient and genes. This era of newer technologies have the potential to improve the nutritional assessment and measures of bioavailability of various nutrients to get sustainable livestock production. The application of these innovative tools and the concepts developed from genomic studies assures to revise the thinking of researches engaged in nutritional science to improve animal health and ultimately the production and recently various clinical trials deals with nutritional research have proved the relationship among diet, health, disease and production.

References

1. Afman, L., and M. Muller. Nutrigenomics: From molecular nutrition to prevention of disease. J. Am. Diet. Assoc. 2006; 106: 569–576.

2. Amin, T., H. Mahapatra, S.V. Bhat and S.P.S. Gulleria. Application of nutrigenomics in food industry: A review. Indian Hortic. J., 2012; 2: 54-59.

3. Brennan, K.M., J.L. Pierce, A.H. Cantor, A.J. Pescatore and R.F. Power. Source of selenium supplementation influences testis selenium content and gene expression profiles in Single Comb White Leghorn roosters. Biol. Trace Elem. Res. 2012; 145: 330-337.

4. Brennan, K.M., J.L. Pierce, A.H. Cantor, A.J. Pescatore and R.F. Power. Source of selenium supplementation influences testis selenium content and gene expression profiles in Single Comb White Leghorn roosters. Biol. Trace Elem. Res. 2012; 145: 330-337.

5. Costa, N.M.B. and C.O.B. Rosa, 2011. Functional foods: Bioactive components and physiological effects. Rubio, Rio de Janeiro, Brazil.

6. Cozzolino, S.M.F. and C. Cominetti, 2013. Biochemical and physiological bases of nutrition in different stages of life in health and disease. 1st Edition, Monole, Sao Paulo, Brazil.

7. Dalmiel, L., T. Vargas and A.R. Molina. Nutritional genomics for the characterization of the effect of bioactive molecules in lipid metabolism and related pathways. Electrophoresis. 2012; 33: 2266-2289.

8. Dauncey, M.J. Recent advances in nutrition, genes and brain health. Proc. Nutr. Soc. 2012; 71: 581-591.

9. Ebrahimi, R., M.F. Jahromi, J.B. Liang, A.S. Farjam, P. Shokryazdan and Z. Idrus, 2015. Effect of dietary lead on intestinal nutrient transporters mRNA expression in broiler chickens. BioMed. Res. Int., Vol. 2015. 10.1155/2015/149745.

10. Everaert, N., Q. Swennen, S.M. Coustard, H. Willemsen and C. Careghi *et al*. The effect of the protein level in a pre-starter diet on the post-hatch performance and activation of ribosomal protein S6 kinase in muscle of neonatal broilers. Br. J. Nutr. 2010;103: 206-211.

11. Garcia, H., A. Morales, A. Araiza, J.K. Htoo and M. Cervantes. Gene expression, serum amino acid levels and growth performance of pigs fed dietary leucine and lysine at different ratios. Genet. Mol. Res. 2015; 14: 1589-1601.

12. Jiang, R.R., G.P. Zhao, J.P. Zhao, J.L. Chen, M.Q. Zheng, R.R. Liu and J. Wen. Influence of dietary nicotinic acid supplementation on lipid metabolism and related gene expression in two distinct broiler breeds of female chickens. J. Anim. Physiol. Anim. Nutr. 2014; 98: 822-829.

13. Kaiser, M.G., S.S. Block, C. Ciraci, W. Fang, M. Sifri and S.J. Lamont, 2012. Effects of dietary vitamin E type and level on lipopolysaccharide-induced cytokine mRNA expression in broiler chicks. Poult. Sci. 2012; 91: 1893-1898.

14. Kaput J., Ordovas J.M., Ferguson L. et al., 2005. The case for strategic international alliances to

15. Maysa., Hanafy, M., El-Sheikh,A.M.H. and E.A. Abdalla.The effect of organic seleniumsupplementation on productive and physiological performance in a local strain of chicken. Egypt. Poult. Sci. 2009; 29(4): 1061-1084.

16. Naji, T.A.A., I. Amadou, R.Y. Zhao, X. Tang, Y.H. Shi and G.W. Le. Effects of phytosterol in feed on growth and related gene expression in muscles of broiler chickens. Trop. J. Pharm. Res. 2014; 13: 9-16.

17. Nicastro, H.L., E.B. Trujillo and J.A. Milner. Nutrigenomics and cancer prevention. Curr. Nutr. Rep. 2012; 1: 37-43.

18. Phillips, C.M. Nutrigenetics and metabolic disease: Current status and implications for personalised nutrition. Nutrients. 2013; 5: 32-57.

19. Sales, N.M.R., P.B. Pelegrini and M.C. Goersch. Nutrigenomics: Definitions and advances of this new science. J. Nutr. Metab., Vol. 2014. 10.1155/2014/202759.

20. Sales, N.M.R., P.B. Pelegrini and M.C. Goersch, 2014. Nutrigenomics: Definitions and advances of this new science. J. Nutr. Metab., Vol. 2014. 10.1155/2014/202759.

21. Swallow, D.M. Genetics of lactase persistence and lactose intolerance. Annu. Rev. Genet. 2003; 37: 197-219.

22. Swanson, K. S., and L. B. Schook. Canine nutritional model: Influence of age, diet, and genetics on health and well-being. Current Nutr. Food Sci. 2006; 2: 115–126.