Emergency Medicine and Trauma Care Journal

Review Article

Akanbi OM, et al. Emerg Med Trauma Care J: EMTCJ-100007.

Animal Nutrigenomics: Opportunities and Challenges for Sustainable Animal Products in Nigeria

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Citation: Akanbi OM (2019) Animal Nutrigenomics: Opportunities and Challenges for Sustainable Animal Products in Nigeria. Emerg Med Trauma Care J: EMTCJ-100007.

Received date: 07 August, 2019; **Accepted date:** 20 August, 2019; **Published date:** 26 August, 2019

Abstract

Nutrigenomics is relatively a new branch of science which involves more review and further research. Therefore, it must be well understood before it is applied in the field of agriculture particularly in animal nutrition.Livestock performance is thought to be affected by genotype (heritable) and environment (non-heritable). Nutrition is among the greatest environmental determinants. Genes are turned on and off according to metabolic signals that the nucleus accepts from internal factors like hormones and external factors like nutrients.Currently, Nutrigenomics which comprisesofthe three crucial-omics stages (Transcriptomics, Proteomics and Metabolomics), is emerging in the branch of livestock to improve feeds that can be matched to genotypes of animals for a better production, productivity and health. Nutrition has always been known to induce metabolic alterations in muscle which are reflected in tissue remodelling, amplified protein turnover, and muscle atrophy. From a production perspective, these alterations influence efficiency of production, egg, milk and meat quality. Recently they have raised their interests on Nutrigenomics to present the "Personalized Nutrition" aiming to advance the health maintenance of animalsin Nigeria. The aim of this paper is to review the opportunities and challenges for the next generation animal nutrition in Nigeria.

Keywords: Animal Nutrition; Challenges; Diets; Genes; Nutrigenomics; Opportunities

Introduction

The genome is the entire deoxyribonucleic acid (DNA) sequence of an organism including structural genes, regulatory sequences and non-coding DNA sequences. The human genome is estimated to encode up to 30 000 genes, and responsible for generating more than 100,000 functionally distinct proteins. Genomics is the systematic study of the genome and is an approach of mapping, sequencing, and analysis of all genes present in the genome focusing on resolving the variation in the genome between individuals. Functional genomics aims to uncover both the functional roles of different genes and how these genes interact with and influence each other in the functional network underlying health and disease. With the completion of the Human Genome Project, it was realized that a new era in biological and medical sciences was beginning. This is often referred to as the 'omics' revolution. New technologies and knowledge from the Human Genome Project were combined with those of established scientific disciplines like pharmacology and toxicology. These combinations are leading to the terms 'pharmacogenomics' and 'toxic genomics'. In the same manner, the introduction of genomics approach in nutritional sciences lead to the scientific area called 'nutrigenomics'. The term Nutrigenomics compiled by Nutrition and Genetics, is a powerful tool that refers to the study of how nutrients or food derived bioactive compounds can affect human's gene expressions through diet[2,6-8]. Nutrigenomics focuses at how SNPs (single nucleotide polymorphisms) interact with diet and diseases. Nutrigenomics is the all-encompassing study of the genome-wide influences of nutrition. Genes are turned on and off according to metabolic signals that the nucleus receives

from internal factors, for example hormones, and external factors, for example nutrients, which are among the most influential of environmental stimuli. Early in evolutionary development, the nutrients that organisms ingested functioned as primitive signals that turned on and off pathways of synthesis or storage during periods of starvation or excess organisms developed into more complex forms of life they retained the ability to respond to nutrient or nutrient/hormonal signals that govern the expression of genes encoding the proteins of energy metabolism, cell differentiation and cell growth. The, albeit scanty, investigations into molecular interactions of feedstuffs have indicated that gene expression is modified by a number of dietary components, including macrocomponents (carbohydrates, proteins, fats and cholesterol), vitamins (e.g., A, B, E, D) minerals (e.g., Fe, Se, Ca) as well asphytocompounds, including flavonoids,isothiocyanates and indoles. The study of how genes and gene products interact with dietary chemicals to alter phenotype and, conversely, how genes and their products metabolize nutrients is called nutritional genomics or "nutrigenomics". From a nutrigenomics perspective, nutrients are dietary signals, detected by the cellular sensor system, that influence gene and protein expression and, subsequently, metabolite production[9-13]. Application of these modern research tools, known as "omics" technologies, should yield new knowledge on the course of molecular processes in animal organisms and a more precise evaluation of the biological properties of feeds.

Approaches of Nutrigenomics in Animal Nutrition

Thisreview is conducted by gathering related information from various data sources through browsing different websites, reputable journal articles, and published and print materials. The analysis has involved twenty-eight scientific writings of which twenty-one are directly talking about nutrigenomics in animal nutrition, production and health, whereas the rest are talking public health nutrition and research related to the field. From the literature concept, the use and impacts of nutrigenomics from the view point of animal nutrition have been synthesized and finally conclusion has been drawn. New tools available in modern research allow nutritionists to screen genetic background through Transcriptomic,Proteomics and Metabolomics are the three crucial stages of nutrigenomics. Tools of transcriptomic (microarray technologies) allowed new information concerning the physiological effect of dietary proteins; proteomics tools (two-dimensional electrophoresis) might be an important tool toexplore the effect of individual amino acid on protein composition. Nutrigenomics clarify that the system of gene interacts with nutrients and how DNA and genetic code affect the needs for certain nutrients and quantities and helps to understand the nutritional effect on gene expression[12-18]. To explore the importance of diet and diet formulation it is a need to understand physiological, biochemical and metabolic pathways and gene expression in livestock including a poultry. Nutrients in food and supplements may affect the expression and even the structure of specific genes. Nutrigenomics application connects multiple disciplines including dietary effects on genome stability, epigenome alterations, RNA and micro-RNA expression, protein expression and metabolite changes, all of which can be studied independently or in an integrated manner to diagnose health status and/or disease trajectory[19-23].

Use of Nutrigenomics in Animal Nutrition

The conventional animal feeds and nutrition study and research largely focuses on correcting deficiencies, animal nutrient relations and responses of animals to specific feeds or nutrients. However, techniques like genomic revolution enable science of nutrition to be related to gene expression. Of the recent advances in omics, applications in animal nutrition are proteomic, metabolomics, and bioinformatics. These are now making their ways to solve the intervening puzzle between nutrient and genes. Hence, understanding the current knowledge about nutrigenomics helps the farm animal nutrition process for efficient and up-to-date technological utilization. In this line, Tryhurn anticipated that the science of nutritional genomics could be one of the important areas in the study of nutrition as nutrients are dietary signals, detected by the cellular[24-28]. The science of nutrigenomics has received much consideration these days due to its potential in preventing, mitigating and treating chronic disease and certain cancers. In the modern science, it has been documented that about 99.9% of human genomes are identical and there is only 0.01% difference that occurs due to single nucleotide polymorphisms (SNPs). According to there are about 3.1 million SNPs with high polymorphic nature present in human genome that create variability among individuals. This SNP database can be used to identify genetic variants within population. Moreover, some types of cancer and cardiovascular diseases are among the most evident pathologies sensitive to nutritional modulation. Cognizant to this, appreciation of the food risk factors is important which will help to diminish the impact of such non-communicable destructive health factors in population[29-33].

Application of genomic principles in a nutrigenomics helps to formulate a specific association between nutrients and genetic factors. Nutrigenomics could be applicable to determine a personal diet (individual nutritional requirements based on the genetic makeup of the person), clarifies diet related disease and could find out the associated genes that are concerned in diet-gene interaction, detects polymorphism of gene that may have significant nutritional and environmental factors on genetic expression. Also through the application of single nucleotide polymorphism clarifies the differentresponses to same nutrient by different individuals and explores the effect of genetic variation on the interaction between diet and disease. Nutrigenomics will relate optimal diet to choose from many and different nutritional availability while nutrigenomics will formulate information for identifying the optimal diet for a given subject[34-38]. On the road to define the optimal diets for an individual's; it is a need to clarify the health status at molecular stage with the consideration of metabolic and epidemiological studies. Nutrigenomics correlates diet, health and genomics in term of phenotypic effect also include different-omics such as proteomics andtranscriptomic[37-44]. Through different molecular and nutritional researches there are

several factors including environmental which are associated with animal health. To evaluate the interaction between diets and genes, DNA microarray techniques and quantitative real-time Polymerase Chain Reaction (PCR) and DNA sequencing can be applied. The interaction between diets and genes could be evaluated through DNA microarray techniques and quantitative real-time polymerase chain reaction (PCR). Nowadays, microarray or DNA chip technology in nutrigenomics research enables to screening large numbers of genes and giving comprehensive picture of the variation of gene expression patterns[45-47]. These profiling techniques allow researchers for examination of nutrient effects which were not possible in the past. Also possible to examine and comparison of gene expression profile, it has now possible to finger print the control mechanisms for all metabolic activities. Presently, in addition to the previous tools oligo-based and cDNA microarray techniques is possible to understand many of the factors controlling the regulation of gene transcription and globally evaluate gene expression profiles by looking at the relative abundance of gene-specific mRNA in tissues; helps to generate information on reproductive, developmental and performance characteristics in livestock. It is well known that dietary manipulations and nutritional strategies are key tools for influencing production and health[48].

According to the investigation of poor quality feed intake which is characterized by nutritional restriction, expression of specific genes associated with protein turnover, cytoskeleton remodelling and metabolic homeostasis was clearly influenced by diet. These changes in expression could be predicted from observed changes in animal growth and physiology during nutrient restriction, the cell level and neuron expression will be studied through microarray technology. According to the finding of Long nutrient restriction during early gestation in beef heifers affects their calves through expression of genes controlling fatty acid transport in adipose tissue and muscle. Unlike application of trans genesis which very expensive nutrigenomics in livestock agriculture can easily be employed with minimum cost and may be effective in increment of growth rate, milk production and composition, feed usage and carcass composition, disease resistance, enhanced reproductive and prolificacy enhancement. The science of genomic research in the areas of proteomic and metabolomics techniques have made possible the understanding of nutrients in food elements, to enable defining the function of nutrient gene interaction at the cell and individual level. Nutrigenomics is the appreciative sense that enables professionals in the field to know how nutrients determine the genetic expression of individuals. The science of nutrigenomics helps in identifying important nutrients such as amino acids, digestive enzymes, hormones, etc which can be synthesized in the animal. Generally, nutrigenomics can bridge the gap between genetic profile and feeding for better conversion efficient in livestockproduction and productivity.

Nutrigenomics in Poultry and Pork Industry

Nutrigenomics approach is carefully selecting nutrients for fine-tuning genes and DNA presents in every cell and every tissue of an animal. It is possible to measure the effects of certain nutritional supplements and how they alter the gene interaction of the body using gene chips that contain the genetic code of animal. Demand of meat (poultry and pork) is increasing rapidly due to globalization and increasing population all over the world and due to increase of cereal cost there is a need to consider the nutrigenomics approach. Researchers are actively involved to increase the feed efficientusingdifferent combination of feed[49]. Diet with glutamine supplement is better for a piglet to modulate the expression of genes that are necessary for intestinal metabolism and function other finding showed that low protein content in diet increase the intramuscular fat by regulating heart fatty acid-binding protein or H-FABP, peroxisome proliferator activated receptor γ or PPARγ gene which enhances the quality of pig meet. Feed and health optimization in chicken farm could be possible through the application of nutrigenomics research. Also it will lead to the implementation of improved precision feeding strategies by the poultry industry[1]. Lipid metabolism in female chicken of two broiler strain could be regulated by nicotinic acid. Transcriptional regulator of gene involved in lipid oxidation and antioxidant gene expression could be induced via vitamin E diet which has an effect to reduce stress and enhance meat quality and can increase immune protection against bacterial lipopolysaccharide associated infection in chicken[50].

Importance of Nutrigenomics in of AnimalProduction, Reproduction and Health

Application of nutrigenomics has a number of advantages in animal nutrition including the feed efficiency, yield of animals, reproduction efficiency and improving of animal immune systems. The possible application of nutrigenomics was reviewed by different authors. Among the components of nutrigenomics, transcriptomic and metabolomics are the potential techniques used to efficiently understand the molecular actions taking place in a genome receiving nutritional signals and responding to them through characteristic metabolic processes in the organism. The nutrient requirement for maintenance and production varies according to genetic variation which enables to apply selection to choose superior animals for feed efficiency[51-56]. The review of indicated that the application of nutrigenomics helps to properly manage nutrients and with the gene of the animal, control the interaction of nutrients with the gene and help to understand how nutrients regulate reproduction describes that the nutrition of animals particularly in aquatic animals, the expression of genes can be altered through modification feeding. From a practical point of view, gene expression studies allow for the identification of pathways and candidate genes responsible for economically important traits. Dietary manipulations and nutritional strategies are key tools for influencing ruminant production. There is a usual belief that nutrition and genetic makeup both strongly influences the reproductive performance of milk animals. This is particularly important during the transition period and early lactation when the animal is particularly sensitive to nutritional imbalances. In addition, in a report of the application of nutrigenomics, particularly

proteomics enhances gene expression in growing animals and improves growth performance. In the shifting situation of animal nutrition, the study of nutrigenomics helps to understand how nutrients and gene expression interact in relation to production and reproduction of animals. A study conducted on steers exposed to restricted nutrition of low-quality feeds has shown that the effects of gene expression were influenced in that steers were not able to respond due to anatomical and physiological stresses of limiting nutrients[57-59]. Moreover, a study conducted by elucidated that this notion of nutrigenomics and study of diet induced gene expression is discovered in which selenium deficiency shown to alter protein synthesis at transcriptional level also elaborated that nutrients can interact with the genome and modify subsequent gene expression. Another study indicated that the regulation of milk fat content in dairy cows can be affected as genes could discern a pattern of those genes that regulate fat digestion and absorption, and which had the most significant influence on milk fat.

The discovery of gene markers which are related to economically important traits like milk, meat, and wool production etc. whose expression can be improved by dietary regimens is a need of today's nutrigenomics research which will help for sustainable livestock production. The science of nutrigenomics has been given more attention in nutrition studies as it is believed that nutrigenomics has a potential to help producing immune system to certain disease and can be way to treat completely chronic diseases like cancer. A general study conducted (2014) indicated that nutrigenomics is the connection that directly correlates food with animal health and determines the phenotype of an individual. These studies are good indicators to illustrate that nutrigenomics can be used to identify the specific markers to manoeuvre gene expression through use of nutrients or their combinations so as to improve productive as well as overall animal potential or performance. In general, the future of nutrition in animals seems to be better dependent on the science of nutrigenomics as it would be instrumental for identification of pathways and candidate genes responsible for dietary induced diseases and ultimately reduction in production losses due to the effects of diseases in animals. These past studies can be fairly taken as virtuous indicators of the potential of nutrigenomics to control diseases and ensure health of individuals, and the current state of knowledge could be springboard for future applied research in animal sciences.

Current Progress of the Area with Emphasis to Developing Countries (Nigeria)

Area of research in farm animals were mainly focusing on nutrient requirement of animal for maintenance, production and reproduction, diet formulation in order to optimize feed and production efficient. (ancient nutrient utilization has strong correlation with farm animal production and which it relates with methane production, proper utilization of nutrient and competition in use for feed, food or fuel. Hence, the intricate interactions between diet and many aspects of animal health is poorly understood. There is a considerable interest in the application of moleculargenetics technology for the inheritable traits of growth rate, body weight, carcass merit, feed intake, milk yield and composition. Proteomics and metabolite techniques can be used for determination of protein and metabolite composition of livestock products. Omics techniques (transcriptomic, proteomics and metabolomics) which helps the current animal production to highlight the metabolic, nutrient status of an animal, act to adjust the metabolism to the nutrient status, in body fluids such as blood and saliva, and in excrements (faeces, urine, breath). Feed cost comprises the variable expense in animal production system making feed efficient\ an important economic consideration stated that gene expression of aetiology of fatty liver in dairy cows at calving and gene expression of gluconeogenesis in early lactation in cow's transcriptome analysis of cattle muscle identifies potential markers for skeletal muscle growth rate and major cell types were understood. According to the finding of the deposition of intramuscular fat (IMF) altered the relationship between the expression of these genes and growth rate. Concentrations of glucose, cholesterol, urea, insulin, insulin-like growth factor- 1, triiodothyronine, and thyroxine (T4) in blood plasma and of lactose and urea in milk were positively correlated with energy balancerevealed that there are direct association between diet composition and dietary nutrient supply and the expression level of proteins. Presently, protein and metabolites level expression measurement, provide new ways and important additional knowledge for determining and managing nutrient balances in farm animals with the determination of nutrient imbalances and these omics techniques in livestock feeding studies is technically feasible, and that the hypotheses for such studies can be translated from similar human studies also helps to optimize diet composition and dietary nutrient supply in defined populations of livestock species or in individual animals. Selecting nutrients for fine tuning genes and DNA present in every cell and tissue of an animal is possible via nutrigenomics. For example, keeping stresses response gene turned off through proper nutrition, as a result animal is healthy and more producer. Therefore, nutrigenomics is a tool to develop animal feed/food matching to is genotype, to select nutrients fine-tuned with genes of animal and to understand the role of nutritional management in performance of animal.The technology holds much promise for providing better nutrition, health and production in both developing and developed countries e.g Nigeria.

Challenges and Opportunitiesin Nigeria

The demand for animal products has been increasing in line with urbanization and population growth. In addition, some of the cereal feeds used for animal production could also be served for humans as well. This phenomenon needs an innovation solution to convert small amount of feed for a production, this may be possible via 'omics' technology. Optimization of productivity and efficient in nutrition utilization could be possible. However, there is limitation in nutrigenomics information how to effectively analyse and correlate genes and nutrition conversion in livestock production. To manipulate this, the genetic potential is partially utilized, the utilization of most nutrients appears to be low and

hence, there is a huge variation in performance. From a Nitro genomics point of view, it is possible to expect to change the way we feed and manage livestock and poultry. Molecular genetics tools having substantial impact in the future include DNA-based tests for genes or markers are affecting traits that are difficult to measure, such as meat quality and disease resistance. This could be used as an opportunity to breed for improvement of production and productivity, such as product quality, increasing animal welfare, disease resistance, disease receptivity and reducing environmental impact. This approach will help the breeder or researcher for a precise determination of nutrient beneath specific condition. The level of expression for a same nutrition is different in individuals. For example, the changes in plasma cholesterol can be due the dietary of cholesterol; however, this expression is dependent upon the individual.

Possible to change the way we feed and manage livestock and poultry that the nutrition is genotype dependent and nutrient could bring expression of genotype. Nonetheless, it is most difficult challenge will appear in establishing these basic relationships and applying them to improving this relationship and applying them to improving the health and production of all individuals at all ages. Nutrigenomics can only provide part of the solution in response to non-genetic factors involved in an individual's health and production.Environmental, cultural and economic factors also play an essential role in individual food choices and accessibility [16]. Malnutrition in the form of under nutrition or obesity can also modify gene expressionand genome stability, resulting in changes in phenotype, and hence it is difficult to choose one population as a reference. The availability of genomic information is important to determine a specific nutrient under specific condition. Usage of this genomic information raises questions on how to apply such knowledge and how to use such information. Interpretation and consideration of genotype of individual for nutritional suggestion financial, ethical and customer preference aspect may affect the revolution of nutrition.

Market scenario of Nutrigenomics in Nigeria

Although the implementation of nutrigenomics remains controversial but the market for nutrigenomics is growing at a tremendous speed. The global nutrigenomics market size was valued at USD 252.20 million in 2017 and the market is expected to reach USD 17,313.5 million by 2023. Nutrigenomics market in Europe is growing at a CAGR of 17% followed by Asia Pacific nutrigenomics market is expected to grow at a CAGR of 17.1% during the forecasted period. Middle East is domination market by holding 64.3% of the Middle East and Africa market share. A study by [3-4] reported that Nigeria population (x1000) in respect to year 2010 to 2015 showed a 12.5% increase and will still grow from year 2015 to 2050 by 54.28% which are higher when compared to values of some selected countries of the word. Examples include, 5.26% and 16.86% for South Africa, 3.40% and 17.25% for USA, 2.23% and 9.48% for France, 7.54% and 28.44% for Australia, 6.11% and 23.12% for India and Germany recording values of 0.31% and -8.29% respectively. Increasing awareness among consumers and prevalence of metabolic diseases, growing trend of personalized diet among athletes, rising obese population and increasing healthcare expenditure and advancements in technology has driven the growth of the nutrigenomics market spontaneously.

Conclusion

This piece of review indicated that nutrigenomics will be a potential to serve as modern tool for nutritional research in mitigating the problems related to animal production and health. Therefore, more knowledge and understanding on how nutrients influence every physiological process in the animal body will be an advantage for nutritional management. Hence, the future innovations in nutritional research with use of various molecular technologies will undoubtedly bring up to date understanding of nutrient gene interrelationship and help to define new methods for managing animal production. Nutrient and food components can affect gene expression/regulation directly and indirectly, transcription and plays a regulatory role in intermediate metabolites of signalling pathways, with positive or negative effects. There is a considerable interest in the application of molecular genetics technology for the inheritable traits of growth rate, body weight, carcass merit, feed intake, milk yield and composition. Nutrigenomics can only provide part of the solution in response to non-genetic factors involved in an individual's health and production.

Author's Contribution

AOM wrote the manuscript. AOM was the principal author who was responsible to manage all activities of the review. OJO and AOA read the second draft of the manuscript. All authors read and approved the final manuscript.

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