

Omics applications in animal nutrition-infection study: a short overview

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Abstract

Dietary intervention has been conducted to ameliorate the bacterial infections in food animals. The assessment of the relationship between nutrition and infection is of importance to better understanding on diseases mechanism. On this knowledge, the prevention and therapeutic strategies may be established. Recently, omics technology have been employed to study the relationship between dietary intervention and infection progress in farm animals. Transcriptomics, proteomics, metabolomics and metagenomics are among the omics technologies that are usefully employed to understand the interaction between nutrition and disease progress.

Keywords: farm animals, disease progress, immune system, nutrition, omics technology

Introduction

Bacterial infection is one of the causes that puts food animals' health and development at risk. Infection can harm an animal's health in addition to affecting its growth. As a result, the latter condition may raise farm morbidity and death rates. Due to the occurrence of antibiotic resistance in both humans and animals, subtherapeutic usage of antibiotics is now forbidden [1]. As a result, such conditions may increase animal morbidity and death, resulting in financial loss for farmers. During the era when farm animals were not given antibiotics, dietary treatments were used to help them fight bacterial infection. Nutrition has been shown to promote the health of broilers through a number of mechanisms. Broilers' immunological abilities, gut microbial balance, and physiological responses may all be improved by dietary intervention [1,2].

The relationship between dietary modification and bacterial infection in farm animals should be investigated. Transcriptomics, proteomics, and metabolomics are some of the omics technologies that have been utilized to molecularly analyze the dietary adaptations of animals to biological systems [3]. Metagenomic sequencing has also been used to investigate how bacterial infections and/or dietary changes affect gut microbial ecology. Overall, omics applications may aid in the molecular understanding of complicated

connections between diet and infection, which is critical for the development of bacterial infection prevention techniques in animals.

Omics technology in animal research

Better management and production strategies are required to meet the need for increased animal production output. Indeed, the improvement in breeder selection programs, meat and dairy product quality, as well as health will all help to increase sustainability and production of food animals [4]. Today, molecular research is promoted in order to discover the most effective and efficient techniques for increasing food animal production and health. Omics methods (e.g., genomics, transcriptomics, metabolomics, and proteomics) are commonly employed in animal studies, especially when it comes to molecular research. These experimental techniques have the potential to lead to new fundamental and applied biological process understandings [5]. In this regard, omics technology may be used to investigate genes, transcripts, proteins, and/or metabolites.

The unchanging sequences of genes and proteins had formerly been discovered through genomic research. Today, the dynamic functions of genes and their interactions have been the focal point of attention. Indeed, the biological function of the gene product can be discovered via transcriptomics, proteomics, and metabolomics. Zampiga et al. [6] pointed out that many qualitative and quantitative characteristics of broilers have been studied and understood by using omics technology. Transcriptomics, proteomics, and metabolomics approaches, in particular, have been successfully used to investigate the molecular basis of complex traits like feed efficiency and muscle myopathies, as well as to investigate molecular responses to nutritional treatments and to assess important aspects of immunity and disease resistance. In term of response to environment, the application of omics technology might help researchers better understand the adaption processes of breeds and/or species towards different environmental conditions [5].

Nutrition-infection research in food animals

The influence of nutrition on the health and well-being of farm animals has long been recognized. Nutrition has been demonstrated to boost animal immunological capabilities in addition to providing growth-supporting nutrients. Nutraceuticals and functional feed additives can both play this latter role. Typically, nutraceuticals are feeds or dietary components that aid in the modification and maintenance of normal physiological processes in the healthy host. These nutraceuticals also aid in the prevention of infectious diseases in the host. Nutraceuticals include isolated nutrients (vitamins, minerals, amino acids, fatty acids, and so on), herbal products (polyphenols, herbs, spices, and so on), dietary supplements (probiotics, prebiotics, synbiotics, organic acids, antioxidants, enzymes, and so on), and genetically modified foods/feeds [1]. Functional feed can be defined as whole feed, fortified, enriched, or improved feed that has potential health benefits beyond basic nutrition. As a result, functional feed must be able to support

poultry health and growth. Functional feed resembles ordinary feed in appearance, but it contains components that promote health and growth [7].

One of the major focuses of the nutritional intervention studies in food animals is on prevention of bacterial infections. The studies are mainly subjected to examine the potential benefits of particular diet or dietary components in enhancing host immunity and reducing the intestinal colonization by pathogenic harmful bacteria. The effects of nutrition on cellular and molecular mechanisms of host defence against bacterial infection as well as the role of nutrition in metabolic regulation involved in the defence (immune) system have also been the concerns of the studies [2]. Tolnai et al. [8] have recently reported that nutraceuticals induced modulations in broiler gastrointestinal tract microbiota, and hence improved intestinal health of broilers. Another study also documented that amino acids, vitamins and minerals can act as growth promoters and improve immune system of poultry [9]. Likewise, the use of *Chlorella vulgaris* and *Spirulina platensis* has been documented to improve the immune and antioxidative properties of poultry [10].

Application of omics technology in animal nutrition-infection research

Recently, nutritional studies have employed some omics technologies including transcriptomics, proteomics and metabolomics to molecularly assess nutritional adaptations to the biological systems of the host [3]. In addition to this, metagenomic sequencing has been applied to elucidate the alteration of gut microbial ecology as a result of bacterial infections and/or dietary changes [11]. It has been known that bacterial infections can activate gene transcription involved in host defence mechanisms to counteract the infectious bacteria [12]. Likewise, nutritional interventions can lead to changes in gene expression (DNA methylation) as well as profound effects on disease-related phenotypes [13,14]. Transcriptomics is the study of a complete set of RNA products transcribed in a given organism and can give a holistic overview on molecular changes (gene expression) to infection (disease) as well as to dietary intervention [3,15]. In this respect, transcriptomics seems to be useful in the studies of nutritional interventions to prevent bacterial infections in farm animals. However, transcriptomics is not yet possible to measure or characterize the whole proteome or metabolome composition of the host [14]. Hence, another omics applications need to be employed to elucidate the changes in proteome or metabolome composition as a result of bacterial infections and nutritional interventions.

It has previously been mentioned that in bacterial infection, the adherence of bacteria to the small intestinal mucosa and the production of enterotoxins play an important role in the pathogenesis. This pathogenesis is most commonly associated with changes in expression, modification or stability of cellular proteins [16]. Given that proteomics is an essential tool for analysis of global protein expression [15], this omics technology is thereby a good approach to obtain more detailed understanding of molecular mechanisms behind biological (bacterial infection) processes or diseases mechanisms [16]. It is known that feed ingredients contain macronutrients

(e.g., carbohydrates, lipids and proteins) and micronutrients (e.g., vitamins, minerals, trace elements) that exhibit influences at RNA, protein and metabolite level in a cell or organism when exposed to these components [3]. Taking the bacterial infection and nutritional interventions together, proteomics could be a good technique to obtain a comprehensive view of changes in protein levels in host cells upon infection by pathogenic bacteria and treatment with nutraceutical feed components. In addition, proteomics may also identify biomarkers that can be useful for early diagnosis or for the development and examination of new therapeutics [3,16].

It has been reported that exposure to pathogenic bacteria, such as pathogenic *Escherichia coli* and *Salmonella*, could alter the metabolic regulation in the body of animals [17]. Concomitant with this, dietary interventions are known to influence host metabolisms [14]. Metabolomics, which is one of the newest omics technology, is a useful tool for identifying all metabolites synthesized by the organisms [13,18]. This technology is also an important method for metabolic characterization of individuals and may deliver metabolic endpoints related to health or disease [3]. In our previous studies, metabolomics was useful to understand the metabolic responses of the piglets upon Enterotoxigenic *Escherichia coli* (ETEC) infections through the changes of metabolome in the porcine plasma [17]. This technology has also delivered interesting insights to understand metabolic responses of animals to dietary interventions [18]. Overall, metabolomics helps to understand how pathogenic bacteria and diet influence host metabolic regulations, and then how diet can be modified (based on the biomarkers discovered) to protect the host from bacterial infections.

As mentioned earlier, bacterial infection is associated with disruption of gut microbial community, and concomitantly, the dietary intervention may modulate the composition and diversity of microbiota in the intestine. To understand the role of microbiota in host health and to find out the strategies to modulate the microbial community for the prevention of bacterial infections, the elucidation of the species variation and/or microbiota diversity in pig intestine is of importance. It is known that metagenomic sequencing represents a powerful alternative for exploring the ecology of complex microbial communities [11]. Hence, metagenomics may provide information on the microbial composition and diversity in the intestine of piglets following bacterial infection and/or dietary interventions.

Conclusion

Overall, omics applications may help to understand complex relationships between nutrition and infection on the molecular basis, and this understanding is essential for the development of prevention strategies against bacteria infection in food animals.

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