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Immunogenetics: Enhancing Disease Resistance in Livestock and Poultry

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Immunogenetics, the study of the genetic basis of immune responses, plays a pivotal role in improving disease resistance in livestock and poultry. By identifying and selecting for genetic traits that enhance immune function, breeders can develop animals with stronger defenses against infectious diseases, leading to improved health, welfare, and productivity. This approach reduces reliance on antibiotics and other medical treatments, addressing concerns about antimicrobial resistance and promoting more sustainable animal husbandry practices. By integrating immunogenetics into breeding programs and livestock management, the agricultural industry can foster healthier, more resilient animal populations, ensuring better production outcomes and advancing sustainability.

Keywords: Immunogenetics, Livestock, Poultry, Antimicrobial resistance, Breeding programs

Introduction

The capacity of an organism to eliminate cancer cells or infectious agents (such bacteria and viruses) and to remain immune to infectious illnesses is referred to as immunity. Hazardous materials such as chemicals, pollen, tumor cells, or other foreign objects that enter the body can also be considered infectious agents. The study of the genetic underpinnings of disease resistance and immunological responses is known as immunogenetics. This field has become quite important. Researchers can increase disease resistance in livestock and poultry, enhancing general health and production, by comprehending how genetics affect immune system performance (Cruse and Lewis, 2010).

1. Genetic Basis of Immune Function

Immune responses in animals are controlled by multiple genes. These genes play a critical role in pathogen recognition, immune signaling, and response to infections. MHC variability among animals can determine their susceptibility or resistance to various diseases, including bacterial, viral, and parasitic infections.

A valuable tool for disease prevention and management, as well as for increasing livestock and poultry output, is genetic resistance to illness. The advent of virulent and drug-resistant bacteria, limitations on the use of antibiotics, and the rise of certain illnesses linked to selection for productive features have highlighted the benefits of genetic resistance. Due to the widespread use of chemotherapeutics, the contribution of genetic resistance to livestock and poultry disease control was formerly restricted (Zekarias *et al*., 2002).

Certain complementary components work similarly and share structural traits. It is possible to classify these proteins into families that may have developed from genes shared by common ancestors. In the major histocompatibility complex (MHC), for instance, the short arm of chromosome 6 is mapped to four genes: C4A, C4B, Bf, and C2. All of these genes are referred to as class III MHC genes. It is upstream of the class I MHC genes (B and C) and downstream of the class II MHC genes (DR, DQ, and DP). The protein sequences of the alternative pathway's C2 and Factor B are quite similar. Both are Mg-dependent serine esterases that take involved in the synthesis of macromolecules that activate C3. The high degree of homology and close functional similarly between the C4A and C4B genes and between the Bf and C2 genes, suggests that duplication of ancestral genes may have resulted in these two sets of genes (Briles *et al*., 1993).

The 120-kilobase (kb) section that contains the class III genes on chromosome 6 is around 390 kb telomeric to HLA-DR and 600 kb centromeric to HLA-B. Certain MHC genes have been shown to segregate more frequently with particular class III gene variations. For instance, the C4A Q0, B1 allotypes have the most prevalent deletion. "Extended haplotypes" are the word used to describe such allele pairings. Numerous autoimmune conditions, including diabetes, membranoproliferative glomerulonephritis, and systemic lupus erythematosus, are linked to the HLA-A1, B8, DR3, C4AQ0, and B1 haplotype. The extended haplotype HLA-B44, DR6 and the haplotypes HLA 835, DR1, C4A3, 2, and BQ0 are frequently affected by the conversion of a C4B gene to a C4A gene, which results in an apparent C4B "null" allele.

Among the complement components, C1 and CB are special since many genes encode these proteins. Together, the C1r and Cls genes are located on chromosome 12, and the serum proteins are serine proteases that are a component of the macromolecule C1. Chromosome 1 contains the gene for C1q, which codes for the third molecule that makes up C1. C8 has three chains: α, ß, and η. The α and ß chains are encoded by closely related genes on chromosome 1, whereas the γ chain is encoded by a gene on chromosome 9. C5 maps to chromosome 9. The C5 protein shares both structure and with C3 and C4. The genes for C6 and C7, both map to chromosome and encode proteins that are structurally related.

Factor H, C4b-binding protein (C4bp), decay accelerating factor (DAF), membrane cofactor protein (MCP), and the complement receptors CR1 and CR2 are all encoded by the group of regulators of complement (RCA) genes on chromosome 1. The amount of identical short consensus repetitions (SCR) of 60–70 amino acids, which show the likelihood of a common ancestor, varies between different inhibitors. The SCRs may attach to C3 fragments, and they are also present on other complement C components (Zekarias *et al*., 2002).

2. Breeding for Disease Resistance

It is feasible to improve the genetic characteristics linked to strong immune systems in poultry and livestock through selective breeding. This comprises:

1. Marker-Assisted Selection (MAS): To create populations with improved immunity, animals might be chosen for breeding programs based on genetic markers associated with disease resistance.
2. Genomic Selection: Cutting-edge tools like genome-wide association studies (GWAS) assist in locating certain genes or areas linked to increased resistance to illness. Breeders can more precisely estimate an animal's potential for disease resistance thanks to genomic selection technologies (Pal *et al*., 2019)

3. Applications in Livestock

Immunogenetics has been used to produce cattle that are more resistant to respiratory illnesses in cows, mastitis, and TB. Cattle MHC gene variations, for instance, have been connected to resistance to viral and parasitic diseases. To increase resistance to illnesses like African Swine Fever (ASF) and Porcine Reproductive and Respiratory Syndrome (PRRS), swine breeding programs are employing genetic markers. Improving disease resistance can increase biosecurity and lessen the effects of epidemics. Immunogenetics helps farmed fish species, such tilapia and salmon, become more disease-resistant. Genetic selection has been used to increase production efficiency and survival rates by decreasing sensitivity to common diseases (Mallard *et al*., 2015)

4. Applications in Poultry

The field of avian immunogenetics studies the genetic resistance of chickens to viral infections such as Newcastle disease, avian influenza, and Marek's disease. In order to create robust poultry lines, breeding tactics use the genes that have been linked by research to improved immune responses in chickens. Another important component of disease resistance in chickens is gut health, which is influenced by genetic variables. A healthy gut is the foundation of a robust immune system, and breeding initiatives currently focus on genes that improve the balance of gut bacteria, which lowers the need for antibiotics (Kim and Lillehoj, 2019).

5. Benefits of Immunogenetics

- Decreased Antibiotic Use: Antibiotic resistance in people and animals is addressed by breeding animals with innate disease resistance, which reduces the requirement for antibiotics.
- Better Animal Welfare: Strong immune-system-bred animals enjoy better lives and suffer from fewer diseases, which enhances animal welfare overall.

Economic Gains: The cattle and poultry sectors profit financially from decreased veterinarian expenses and increased output brought about by fewer disease outbreaks and improved survival rates.

6. Future Directions

- CRISPR and Gene Editing: By directly altering genes linked to immune function, technologies such as CRISPR/Cas9 provide new opportunities for improving disease resistance. Without the lengthy processes involved in conventional breeding, this can hasten the creation of animals immune to illness.
- Host-Pathogen Co-evolution Studies: Improved breeding programs and vaccination tactics may be developed with a greater understanding of how viruses change in response to host immune responses.

Conclusion

Immunogenetics provides effective methods for enhancing disease resistance in poultry and cattle, leading to significant improvements in animal welfare, health, and productivity. By leveraging genetic insights, breeders can produce animals with stronger immune systems, reducing susceptibility to diseases. This approach lessens the need for antibiotics and other medical interventions, which in turn addresses concerns about antibiotic resistance and supports more sustainable farming practices.

Integrating immunogenetics into breeding programs not only enhances herd and flock health but also improves overall farm efficiency. Healthier animals lead to lower mortality rates, reduced veterinary costs, and increased productivity. Moreover, robust disease-resistant livestock minimizes the risk of disease outbreaks, contributing to more stable and predictable production cycles. This holistic approach not only promotes sustainability but also ensures ethical animal husbandry by prioritizing animal welfare while maintaining high production standards.

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