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Genetic Resistance to Zoonotic Diseases in Livestock

Hemlata Chouhan[1*], Rashmi [2], Pravin Bano[3], Priyanka Karela[4] and Renu[5]
[1]Assistant Professor, Department of Animal Genetics & Breeding, CVAS, Navania
[2]Assistant Professor, Department of Veterinary Pathology, CVAS, Jodhpur
[3]Assistant Professor, Department of Veterinary Pathology, CVAS, Bikaner
[4]Assistant professor, department of veterinary medicine, CVAS, Bikaner
[5]Assistant Professor, Department of Veterinary Pathology, PGIVER, Jaipur
*Corresponding author Email: dr.hemlatachouhan@gmail.com
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Abstract

Zoonotic disease is threat to both animals and human beings. Zoonotic disease can spread via humans to animals and its vice-versa through vectors and without vectors. In some animals genetically few modifications are present which provide resistance to infectious and zoonotic disease naturally. Genetic resistance is a sustainable approach to controlling zoonotic diseases in livestock by selective breeding animals with naturally stronger disease resistance, leading to healthier herds and improved livestock production for disease resistance animals. Genetic resistant animals have resistant gene; these genes may control one disease resistance or more than one disease. Molecular and advance techniques are used to identification of these genes and their functions. Advances in genomics, breeding and gene editing are making disease-resistant livestock increasingly achievable, offering significant benefits for sustainable animal agriculture; reduce zoonotic disease occurrence in animals and human, good impact on animals and human health and global food security. Identification and implementation of genetic resistance in livestock have faces some issues but use of modern techniques are become more beneficial.

Keywords: Genetic resistance, zoonosis, disease and gene

INTRODUCTION

Zoonotic diseases:-

Zoonotic diseases can be transmitted through animal to humans and it's vice versa humans to animals via any vector like ticks, mosquitoes and without any vector. Zoonotic diseases play significant challenges to animal health, public health, and food security.

Genetic resistance:-

Genetic resistance is the inherited capability of livestock to naturally resist diseases like zoonotic and infectious diseases by specific genetic makeup or genes.

IMPORTANCE FOR ZOONOTIC DISEASE CONTROL

Disease-resistant livestock can:

- Reduce pathogen shedding into the environment.
- Lower the risk of transmission to humans and other animals.
- Decrease reliance on antibiotics and antimicrobial drugs.
- Improve animal welfare and productivity.
- Enhance food safety and public health.

A number of advantages of incorporating genetic elements in disease management strategies have been recognized (FAO, 1999) including:

a. Once the genetic resistance is established these changes become permanent in genetic flow.
b. The possibility of broad spectrum effects like increasing resistance to more than one disease is adding to the diversity of disease management strategies.

Disease can be genetic managed according to availability of resources and nature of problem. Diseases resistance strategies may include choosing the appropriate livestock breed for the production environment; elite or desirable animals are selected for cross-breeding to introduce genes into breeds; and individuals have high levels of disease resistance or tolerance selected for breeding purpose. Breeds reported to DAD-IS as showing resistance or tolerance to trypanosomiasis cattle breeds (17), sheep (4), goat (4) in African countries.

Breeds reported to DAD-IS as showing resistance or tolerance to tick-burden cattle breeds (17), buffalo (1) and dear (1) shown in the world (FAO, 2007).

Vaccination and other veterinary assistant for disease control are conventional disease control strategies which are commonly used to control disease conditions and prevention strategies. Along with all the efforts to prevention and diseases control; inherent ability of animal to resist, tolerate and remain resilient to disease catches more focus nowadays.

HOW GENETIC RESISTANCE WORK

Disease resistance genes developed the resistant quality in animals likely to become infected or develop severe disease and provide a sustainable strategy to reduce disease prevalence, resist infection, reduce disease severity, minimize pathogen transmission, tolerate disease with minimal health and productivity losses and strengthen the One Health framework for animals, humans and environment.

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Genetic resistance is permanent and can be passed on to parents to off-springs or next generations. In livestock, breeding focus on the disease resistance by identification and selection of naturally superior resistant animals to infectious agents is increasingly viewed as a sustainable strategy to improve animal welfare, reduce antimicrobial use, and limit transmission of zoonotic pathogens to humans.

Genetic control mechanisms for resistance/tolerance in farm animals to specific viral, bacterial, parasitic and prion diseases was completed on cows, sheep and goats, pigs and poultry. The importance of genetically heterogeneous populations is highlighted, particularly as they impact response to epidemics, their duration, lower mortality rates, etc. Genetic resistance in farm animals to a variety of etiological infectious agents can be determined at three genetic levels of variation: species, breed and unique genetic variation among individual animals (Jovanović *et al*, 2009).

Genetic resistance to animal disease, i.e. the heritable diversity in the susceptibility of species, breeds and individuals, has been recognised for a long time, but still this knowledge is not implemented to get more benefits in livestock breeding and production (Muller et al, 2000).

Key Points / Importance Of Genetic Resistance:

1. Diseases resistant animals reveal lower disease susceptibility and faster recovery example like indigenous cattle breeds shows greater resistance to ticks, heat and infectious diseases than many exotic breeds.
2. Selective breeding emphasis on healthier and more disease-resistant livestock for next generation diseases such as Mastitis Bovine Tuberculosis and Brucellosis.
3. Genetic resistance helpful in reduction of the use of antibiotics and lowers disease transmission.
4. Healthy and disease resistance animals show improves productivity, animal welfare, and farm profitability.
5. Genetic resistance is controlled by specific genes that strengthen the immune system generation to generation.

Advantages:

1. Livestock become more healthier
2. Economically advantageous
3. Ensure food safety
4. Reduce the risk of zoonotic disease transmission to humans

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In modern genetics, quantitative genetics, genomics, immune-genomics and gene-editing technologies are used to understand host- pathogen interactions, animal immune response and

MODERN GENOMIC APPROACHES

1) **Marker-Assisted Selection (MAS):-**

   Animals that carry desirable disease-resistance genes are selected.

   Advantages:

   a) more accuracy
   b) Faster selection
   c) Reduced need for challenge testing

2) **Genomic Selection**

   Superior breeding animals are selected by use of genome wide markers.

   Advantages:

   a) Earlier selection of breeding stock
   b) disease resistance predication can be improved

3) **Genome-Wide Association Studies (GWAS)**

   Identify genetic regions associated with resistance by comparing resistant and susceptible animals.

4) **Gene Editing**

   Gene editing is a group of technologies that change the DNA by two methods:-

   a) Gene knock-in
   b) Gene knock -out

   Tools such as CRISPR -Cas9 allow precise modification of resistance genes while maintaining productivity.

   Examples: PRRS-resistant pigs

ONE HEALTH PERSPECTIVE

The integration of animal genetics into disease-control programs supports:

a. Disease resistance improve animal health through improved resistance.
b. Reduction in zoonotic diseases affects human health in positive manner.
c. Environmental health and genetic- environmental interaction will improve through reduced chemical and antibiotic use.

GENETIC RESISTANCE MATTERS

Zoonotic diseases in livestock can cause:

- Reduction in productivity (milk, meat, eggs, wool)

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- Increased mortality due to zoonotic disease and after effect of disease
- Increases the veterinary costs and management
- Food security concerns
- Transmission of zoonotic diseases to humans.

Genetic resistance provides a long-term, environmentally friendly complement to vaccination, biosecurity, and disease management.

MECHANISMS OF GENETIC RESISTANCE

1. Enhanced Innate Immunity

- Some genes like Toll-like receptor (TLR) genes, Cytokine-related genes and Antimicrobial peptide genes that improve early pathogen recognition and destruction.

2. Adaptive Immune Response

Variation in genes like Major Histocompatibility Complex (MHC) genes and immunoglobulin-related genes involved in antibody production and T-cell responses can affect susceptibility.

3. Receptor Modification

Specific host receptors are requires to pathogen for enter in cells. By modern technology, genetic variants modified these receptors and reduce infection to animals and humans.

4. Disease Tolerance

In certain animals, complete resistance is absent but also in this conditions animal production is maintained and economical losses are reduced.

RESISTANCE TO ZOONOTIC DISEASES

Particular attention is given to diseases that can infect humans:

S.No.	**Disease**	**Livestock Species**	**Human Risk**
1.	Bovine tuberculosis	Cattle	High
2.	Campylobacteriosis	Poultry	High
3.	Q fever	Sheep, goats, cattle	High
4.	Salmonellosis	Poultry, pigs, cattle	High
5.	Brucellosis	Cattle, sheep, goats	High

Breeding livestock with increased resistance may:

- Lower pathogen prevalence
- Reduce environmental contamination
- Decrease foodborne transmission
- Support One Health initiatives linking human, animal, and environmental health.

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CHALLENGES

Despite its promise, breeding for disease resistance faces several challenges:

1. Resistance is often controlled by many genes.
2. Pathogens evolve rapidly.
3. Resistance to one disease may not protect against others diseases.
4. Genetic correlations with production and economic traits can occur.
5. Disease resistance measurement is difficult in large populations.

RECOMMENDATIONS FOR FUTURE WORK

New technologies are accelerating progress:

- Whole-genome sequencing (GWAS)
- Functional and structural genomics
- Transcriptomics and proteomics
- Artificial intelligence-assisted breeding
- Precision sustainable livestock farming
- Gene editing technologies both gene knock in and gene knock out.

Combine genomic selection, biosecurity measures and advanced diagnostics to produce livestock populations that are both highly productive and more resistant to infectious and zoonotic diseases.

CONCLUSIONS

Genetic resistance represents a powerful and sustainable tool for combating infectious and zoonotic diseases in livestock. By combining genomic research, advanced breeding technologies, conservation of indigenous genetic resources, animal husbandry and livestock industries can contribute significantly to reduction in zoonotic disease, ensuring healthier animals, safer food systems, better protection of human populations from zoonotic threats and achieves the one health goals.

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