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Improving Disease Resistance in Tilapia: Genetic Solutions for a Sustainable Industry

Roux Anal*

College of Agriculture and Life Sciences, University of Vermont, Burlington, Vermont, USA

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Introduction

Tilapia is one of the most widely farmed fish species globally, prized for its fast growth, adaptability, and economic value [1]. However, disease outbreaks continue to pose significant threats to the sustainability and profitability of tilapia farming, often leading to high mortality rates and economic losses. To address this challenge, genetic solutions are emerging as a promising approach to enhance disease resistance in tilapia [2]. Through techniques such as selective breeding, genomic selection, and biotechnology, researchers and aquaculture professionals aim to develop robust tilapia strains with improved immunity and resilience to pathogens [3]. By reducing the dependency on antibiotics and chemical treatments, these genetic advancements contribute to more sustainable and environmentally friendly fish farming practices. Improving disease resistance through genetics not only supports industry growth but also helps ensure food security and the long-term health of aquatic ecosystems [4].

Discussion

Enhancing disease resistance in tilapia through genetic approaches is increasingly recognized as a sustainable solution to one of aquaculture's most pressing challenges [5]. Disease outbreaks, such as those caused by Streptococcus spp., Francisella spp., and Tilapia Lake Virus (TiLV), have led to substantial losses in tilapia production worldwide. Traditional disease management methods relying heavily on antibiotics and chemical treatments pose environmental risks and can contribute to the development of antimicrobial resistance [6]. As a result, genetic improvement has emerged as a forward-looking alternative that offers long-term resilience without compromising ecological integrity. Selective breeding programs, which have been successfully used in livestock and other aquaculture species, are being adapted for tilapia to enhance innate resistance to common pathogens [7]. These programs focus on identifying and propagating fish with naturally stronger immune responses, leading to cumulative improvements over generations [8]. Advances in molecular biology and genomics, such as marker-assisted selection and genomic selection, have significantly accelerated this process by enabling the identification of specific genes or markers associated with disease resistance [9].

Moreover, biotechnology tools like CRISPR and transgenesis, although still in the early stages of application for tilapia, show potential for precise genetic interventions that could confer resistance traits more effectively. However, ethical considerations, regulatory frameworks, and public perception continue to influence the pace at which such technologies are adopted. Importantly, integrating genetic solutions with good aquaculture practices—such as biosecurity, vaccination, and water quality management—can produce synergistic effects, further minimizing the risk of disease outbreaks. Overall, improving disease resistance in tilapia through genetic innovation not only enhances productivity and profitability but also supports the shift toward more sustainable and responsible aquaculture systems [10].

Conclusion

Genetic improvement for disease resistance in tilapia represents a critical advancement toward achieving sustainable and resilient aquaculture. By leveraging selective breeding, genomic tools, and emerging biotechnologies, the industry can reduce its reliance on antibiotics, lower production losses, and enhance fish health and welfare. These innovations offer a long-term, environmentally responsible strategy to combat persistent disease threats, ensuring stable yields and economic viability. As research progresses and genetic programs become more widely adopted, integrating these solutions with strong farm management practices will be essential to realizing the full potential of a healthier, more sustainable tilapia industry.

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***Corresponding author:** Roux Anal, College of Agriculture and Life Sciences, University of Vermont, Burlington, Vermont, USA, E- mail: rouxanal@gmail.com

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