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Next-generation biosecurity: biomolecular innovations for sustainable aquaculture

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Abstract:

The COST BioAqua initiative highlights the role of advanced molecular diagnostics, such as real-time PCR and CRISPR-based tools, in achieving rapid and precise pathogen detection. Additionally, genetic engineering strategies, including selective breeding for disease resistance, and the use of probiotics and microbiome modulation, contribute to enhanced immune responses and overall fish health. Furthermore, next-generation vaccines and antimicrobial peptides are emerging as vital alternatives to antibiotics, mitigating the risks of antimicrobial resistance. Biosecurity is a fundamental component of aquaculture management, essential for preventing disease outbreaks, reducing economic losses, and ensuring sustainability. However, numerous challenges—ranging from inadequate health regulations to evolving pathogen threats—hinder the implementation of effective biosecurity measures. A critical issue remains the lack of comprehensive regulatory frameworks in aquaculture, making it difficult for fish farmers to adopt standardized biosecurity protocols. By integrating biomolecular innovations with regulatory improvements, aquaculture can enhance its resilience to disease threats, safeguarding both productivity and environmental sustainability.

Keywords: aquaculture biosecurity, biomolecular innovations, molecular diagnostics