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Role of Biotechnology in Ensuring Food Safety in the Meat Sector

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Abstract: Food safety is a critical concern in the meat sector due to the potential risks associated with microbial contamination, chemical hazards, and food borne illnesses. Biotechnology offers promising solutions to enhance food safety measures by improving the detection, prevention, and control of food borne pathogens and contaminants. This review article discusses the significant contributions of biotechnology in ensuring food safety in the meat sector. It highlights various biotechnological approaches such as rapid detection methods, genetic engineering, probiotics, and antimicrobial agents employed to mitigate food safety risks in meat production. The article also examines the challenges and prospects of biotechnology in enhancing food safety and consumer confidence in the meat industry.

Introduction

Food safety is a global concern, particularly in the meat sector, where the risk of microbial contamination and the presence of chemical hazards pose significant health risks to consumers. Biotechnology has emerged as a valuable tool in addressing these challenges and ensuring the safety of meat products. This section provides an overview of the importance of food safety in the meat industry and introduces the role of biotechnology in mitigating food safety risks.

Pathogen detection and control

Molecular techniques

Polymerase chain reaction

Through PCR important analysis is done in the area of interest for both identifying food adulteration and preserving concerning human health & animals. PCR is used to identify distinct animal species in meat and dairy products, and detection is applied for toxicogenic fungi and foodborne pathogens, and genetically modified organisms (GMOs) in various matrices. Starting with DNA isolation modified for various matrices, target gene identification, and validation for all of these approaches are used to demonstrate the working processes and result analysis. Techniques include simplex PCR techniques, primer multiplexing, primer design, validation of laboratory procedures, optimization of PCR findings, and result interpretation through the study of electrophoresis gels and sequencing data.

Next-generation sequencing (NGS)

A DNA analysis technology called "next-generation sequencing" (NGS) has been acknowledged as one of the most trustworthy methods for animal classification. The untargeted nature of NGS allows for the simultaneous production of millions of sequences from individual sequences using various templates, allowing for the detection of thousands of species in each sample. Since universal primers rather than taxa-specific primers are utilized, there is no requirement for prior knowledge of which target to seek for. New NGS platforms are being created to revolutionize the assessment of food authenticity because it is a developing technology.

Rapid on-site detection method

Nanotechnology

Nanotechnology is now invading the food industry and establishing great potential. Nanotechnology applications in the food industry include encapsulation and delivery of substances in targeted sites, increasing the flavor, introducing antibacterial nanoparticles into food, enhancement of shelf life, sensing contamination, improving food storage, tracking, tracing, and brand protection. Nano food processing and products can change the color, flavor, or sensory characteristics; they also change the nutritional functionality and removes chemicals or pathogens from food. Nano food packaging materials may extend food life due to high barrier packaging, improve food safety, alert consumers that food is contaminated or spoiled, repair tears in packaging, and even release preservatives to extend the life of the food in the package. Nanobarcodes are used for safety labeling and monitoring the distribution of food products. Nanosupplements can be easily incorporated by encapsulation techniques for nutritional and drug delivery systems effectively.

Immunoassays

To identify naturally occurring components, microorganisms, and fragments of microbial constituents related to food analysis, food production, food processing, and food safety, immunoassay techniques have been developed and and applied in the food industry. The development of various immunoassay techniques, such as the enzyme-linked immunoassay (ELISA) and radioimmunoassay (RIA), uses both polyclonal and monoclonal antibodies. Immunoassay methods offer supplementary and/or alternative methods for analyzing data more quickly and with more reliability while using less expensive, complex equipment. In their most basic forms,immunoassay techniques make great screening instruments for locating contaminations and adulteration. The application of immunoassay techniques contributes tremendously to the quality control and safety of our food supply.

Biological control agents

Probiotics and Antimicrobial Agents

Probiotics and antimicrobial agents play a crucial role in promoting food safety by inhibiting the growth of harmful pathogens in meat products. This section reviews the use of probiotics, such as lactic acid bacteria, as natural antimicrobial agents to control the growth of pathogens. It also discusses the utilization of antimicrobial agents derived from natural sources, including bacteriocins and essential oils, to ensure the safety and shelf-life of meat products.

Bacteriophages

Bacteriophages have been used to control pathogenic bacteria in man and animals with varying degrees of success. Bacteriophages are widespread in the environment (Rohwer and Edwards, 2002); numerous studies have shown that Bacteriophages penetrate the human food chain and are regularly consumed without any apparent adverse effects; (Kennedy and Bitton, 1987); Therefore, the use of those substances as bio control agents in foods is not adding new organisms to the food chain. A vast number of new products have been developed with the recent approval by the United States Food and Drug Administration to treat phages in food, which are intended to decrease or eliminate zoonotic diseases and spoilage bacteria. However, they have not yet been formally approved by the EU and there is a debate as to their legal status as either food additives or processing aids, (Jagvonow and Teufer, 2007), respectively.

Genetic modification for food safety

Genetic Engineering

Genetic engineering offers potential solutions to enhance food safety in the meat sector. This section explores the use of genetic engineering techniques to develop animals with enhanced resistance to pathogens or reduced susceptibility to foodborne illnesses. It discusses the development of genetically modified organisms (GMOs) with improved traits, such as increased disease resistance, reduced bacterial contamination, and enhanced meat quality.

Challenges and Future Perspectives

Implementing biotechnological approaches in the meat sector presents various challenges, including regulatory issues, public perception, and consumer acceptance. This section addresses these challenges and provides insights into the prospects

of biotechnology in enhancing food safety. It discusses the importance of addressing safety concerns, ensuring proper risk assessment, and promoting transparency and communication to build consumer confidence in biotechnological interventions.

Conclusion

Biotechnology has revolutionized the field of food safety in the meat sector by offering effective tools for pathogen detection, genetic enhancement, and antimicrobial interventions. The adoption of biotechnological approaches has the potential to improve the safety, quality, and sustainability of meat products. However, it is crucial to address the challenges and concerns associated with biotechnology to ensure its responsible and ethical application. Continued research, collaboration between stakeholders, and regulatory frameworks are necessary to harness the full potential of biotechnology for enhanced food safety in the meat industry.

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