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MICROBIAL RISK ASSESSMENT IN STORED AGRICULTURAL PRODUCTS: ENSURING FOOD SAFETY THROUGH PREDICTIVE MODELING

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Abstract: Microbial contamination in stored agricultural products poses serious threats to food safety and public health. This study aims to assess microbial risks during storage using predictive modeling tools that simulate microbial growth under varying environmental conditions. The research outlines common pathogens, critical control points in storage systems, and evaluates existing mitigation strategies. The findings highlight the importance of integrated microbial monitoring systems and suggest tailored interventions to reduce contamination and ensure food safety.

Key words: Microbial risk, food safety, predictive modeling, agricultural storage, contamination, pathogens, shelf life.

Introduction: The increasing global demand for safe agricultural products necessitates rigorous food safety measures across the supply chain, particularly during storage. In many developing countries, inadequate storage conditions contribute significantly to microbial contamination, resulting in economic losses and public health concerns. Microbial risk assessment (MRA) has emerged as a scientific tool to evaluate and predict contamination risks, aiding in the development of effective safety strategies. This paper investigates microbial threats in storage, the role of MRA, and how predictive modeling supports contamination control.

Literature Review: Several researchers have highlighted the prevalence of microbial hazards in stored grains, fruits, and vegetables. Aspergillus, Penicillium, Escherichia coli, and Salmonella are frequently detected in improperly stored commodities. According to [1], poor ventilation and high humidity accelerate fungal growth in cereals. Moreover, [2] emphasized that predictive models using temperature and moisture variables can accurately forecast microbial behavior in storage systems. Advances in quantitative microbial risk assessment (QMRA) have also provided frameworks for estimating the probability of illness due to consumption of contaminated products [3].

Theoretical Framework: This research is grounded in the principles of QMRA, which integrates hazard identification, exposure assessment, dose-response relationships, and risk characterization. QMRA provides a structured pathway to analyze how environmental and handling factors influence microbial dynamics. It facilitates the use of mathematical models to simulate pathogen proliferation, thus aiding food technologists and storage managers in preemptively addressing risks.

Research Questions: What are the most common microbial hazards found in stored agricultural products?
How do storage conditions affect microbial growth and contamination levels?
Can predictive models effectively quantify microbial risks and inform intervention strategies?

Methodology: The study employs a qualitative review of peer-reviewed articles and case studies related to microbial contamination in stored food products. Data on temperature, humidity, and microbial load from various sources are used to compare the performance of predictive modeling tools such as ComBase, Pathogen Modeling Program (PMP), and artificial neural networks

(ANN). Interviews with postharvest managers and laboratory microbiologists provided contextual insights into local challenges.

Findings and Discussion: *Common Microbial Hazards*

Bacteria such as Salmonella enterica, Listeria monocytogenes, and E. coli O157:H7 are recurrent contaminants in poorly stored food products. In grains, Aspergillus flavus leads to aflatoxin production, posing carcinogenic risks. Pathogen presence is strongly influenced by the moisture content, pH, and temperature of the storage environment.

Influence of Storage Conditions

Storage environments exceeding 25°C and 70% relative humidity were associated with exponential microbial growth. Airtight containers and low-humidity storage facilities reported significantly lower microbial counts. Regular aeration and packaging with antimicrobial properties also contributed to extended shelf life.

Predictive Modeling in Practice

Models such as PMP and ComBase demonstrated high reliability in simulating microbial growth curves under controlled conditions. Their predictive accuracy improved with input of local environmental data. While artificial intelligence-based models offer superior adaptability, they require extensive training datasets. Nonetheless, all tools successfully guided hazard analysis and decision-making.

Conclusion: Microbial risk assessment plays a crucial role in ensuring food safety during the storage of agricultural products. Predictive modeling tools provide accurate insights into contamination risks and support the design of preventive measures. By implementing evidence-based storage protocols and real-time monitoring systems, the agricultural sector can significantly reduce postharvest losses and safeguard public health. Future research should focus on integrating machine learning with real-time sensor data to enhance the responsiveness of microbial control systems.

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