JOURNAL OF INTERNATIONAL SCIENTIFIC RESEARCH
Volume 3, Issue 6, November 2025 Online ISSN: 3030-3508
https://spaceknowladge.com

MODERN TECHNOLOGIES IN ENSURING THE MICROBIOLOGICAL SAFETY OF FOOD PRODUCTS

Erkinova Mubina Vahob qizi
Umarqulova Gulhayo Ilhom qizi
Norqulova Zohida T.
Faculty of Industrial Technology

MAQOLA MALUMOTI

MAQOLA TARIXI:

Received:28.11.2025
Revised: 29.11.2025
Accepted:30.11.2025

KALIT SO'ZLAR:

Microbiological safety, food technology, HPP, PEF, bioprotection, ozonation, UV, smart packaging, pathogens, shelf life.

ANNOTATSIYA:

This article discusses modern technologies used to ensure the microbiological safety of food products, mechanisms for eliminating pathogenic microorganisms, innovative control methods, and strategies for reducing potential hazards in production processes. The study analyzes the advantages and application areas of high-pressure processing (HPP), pulsed electric fields (PEF), ozonation, ultraviolet radiation, bioprotection, and smart packaging technologies.

Food quality and safety are crucial factors in maintaining public health. Foodborne pathogens such as Salmonella, Listeria monocytogenes, Escherichia coli O157:H7, and Staphylococcus aureus remain significant global challenges. Although traditional thermal treatments are widely used, their negative impact on sensory characteristics has increased the demand for new technologies. Therefore, non-thermal (minimal processing) modern methods are being rapidly integrated into the food industry.

1. High Pressure Processing (HPP):

HPP is used to inactivate microorganisms by treating food at pressures ranging from 100 to 600 MPa.

Advantages:

No heat treatment is required, preserving natural taste and vitamins;

Effectively eliminates pathogenic and spoilage microorganisms;

Widely applied in cheeses, juices, meat products, and seafood;

Extends shelf life by 2–5 times.

Microbial inactivation mechanism:

High pressure disrupts cell membranes, denatures proteins, and halts metabolic processes.

2. Pulsed Electric Fields (PEF):

PEF is an efficient method used mainly for liquid products such as juices, milk, and nectars.

Principle of operation:

Short high-voltage pulses induce electroporation in microbial cell membranes.

Advantages:

Operates at low temperatures;

Preserves natural color, flavor, and vitamins;

Environmentally friendly alternative to thermal processing;

Low energy consumption.

3. Ozonation:

Ozone is a strong oxidizing agent that inactivates bacteria, molds, viruses, and yeasts.

Applications:

Washing fruits and vegetables;

Surface decontamination of meat products;

Purifying water and air systems.

Advantages:

Leaves no chemical residues (decomposes rapidly);

Environmentally safe;

Highly effective against Listeria and Salmonella.

4. Ultraviolet (UV-C) Radiation:

UV-C radiation (254 nm) damages DNA and RNA, preventing microbial replication.

Applications:

Water disinfection;

Sterilization of liquid products and surfaces;

Increasingly used for bread, herbs, and dairy products.

Limitations:

Limited penetration depth; effective primarily for surface treatment.

5. Bioprotection — using beneficial microorganisms:

Bioprotection involves applying probiotic or bacteriocin-producing microorganisms that inhibit the growth of harmful microflora.

Advantages:

Acts as a natural preservative;

Ensures protection without chemical additives;

Applied in dairy, meat, fish, and bakery products.

Commonly used protective strains:

Lactobacillus sakei

Lactococcus lactis

Pediococcus acidilactici

6. Smart and Active Packaging Systems:

Modern packaging not only ensures microbiological safety but also provides information about the actual condition of the product.

Types:

1. Antimicrobial packaging – incorporates silver ions, essential oils, or organic acids;

2. Sensor-based packaging – indicates spoilage through color changes;

3. Modified Atmosphere Packaging (MAP) – increases CO_2 concentration to slow microbial growth.

Advantages:

Real-time monitoring of safety;

Significant extension of shelf life.

7. Rapid microbiological detection methods:

In addition to classical culture-based methods, the following innovative technologies are widely used:

PCR (Polymerase Chain Reaction) – detects pathogen DNA within 1–3 hours;

ELISA (Enzyme-Linked Immunosorbent Assay);

Biosensors – detect bacteria in real time;

Next-Generation Sequencing (NGS) – provides full microbiota profiling.

Ensuring the microbiological safety of food products is one of the most important tasks of the modern food industry. Technologies such as HPP, PEF, ozonation, UV-C radiation, bioprotection, and smart packaging significantly extend shelf life, reduce pathogen levels, and ensure consumer safety. These innovative methods preserve product quality better than traditional heat treatments and improve economic efficiency. In the future, artificial intelligence and automated control systems are expected to further enhance microbiological safety.

References

1. Leistner L., Gould G.W. Hurdle Technologies. Springer, 2016.
2. Barbosa-Cánovas G.V., et al. Nonthermal Processing Technologies for Food. Wiley-Blackwell, 2019.
3. Balasubramaniam V.M. et al. High Pressure Processing of Food: Principles and Applications. Springer, 2020.
4. Ozone Applications in Food Industry. Food Control Journal, 2022.
5. Modern Food Packaging Technologies. Trends in Food Science & Technology, 2021.
6. FDA Food Safety Modernization Act (FSMA), 2022.