



FSSAI Systems in Controlling Microbiological Hazards in Food

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Food safety ensures that food is safe for human consumption and free from harm, yet it is constantly challenged by biological, chemical, and physical hazards. Biological hazards such as pathogenic bacteria, viruses, yeasts, and molds are the leading cause of foodborne illnesses, with common pathogens like *Salmonella*, *E. coli*, *Listeria monocytogenes*, and *Staphylococcus aureus* posing major threats worldwide. The burden is significant: in the U.S., about 48 million people suffer from foodborne diseases annually, while in India the economic cost is estimated at \$28 billion. To address this, India established the Food Safety and Standards Authority of India (FSSAI) under the Food Safety and Standards Act, 2006, consolidating earlier laws into one science-based regulatory body. FSSAI oversees all aspects of food, from manufacture to import, through regulations, operational controls, surveillance, and emergency response mechanisms to manage microbiological hazards and safeguard public health.

Understanding microbiological hazards and their proliferation

Microbiological hazards cause foodborne illnesses through two primary mechanisms: foodborne infections and foodborne intoxications. Infections occur when a person consumes food containing live pathogens, which then grow in the human intestine and cause disease, with symptoms often appearing after a delay. Intoxications result from consuming food containing toxins produced by pathogens, leading to a rapid onset of symptoms. The growth of these microorganisms is heavily influenced by a set of environmental conditions commonly referred to by the acronym FAT TOM: Food (nutrients), Acidity (pH level), Temperature, Time, Oxygen, and Moisture (water activity). A critical concept in controlling microbial growth is the 'Danger Zone', a temperature range between 5°C and 60°C where microorganisms multiply rapidly. FSSAI's control systems are largely designed to manipulate these factors to inhibit or eliminate microbial threats throughout the food production and handling process.

The FSSAI Framework

FSSAI's strategy for controlling microbiological hazards is not a single policy but a multi-layered system that combines legal mandates, prescriptive practices, operational controls, and robust monitoring.

1. Legal and Management Systems

The major approach of FSSAI is the mandatory implementation of a Food Safety Management System (FSMS) for all licensed Food Business Operators (FBOs). An FSMS is a systematic approach to controlling food safety hazards and is based on internationally recognized principles, including Good Manufacturing Practices (GMP), Good Hygiene Practices (GHP), and Hazard Analysis and Critical Control Point (HACCP). As stipulated in the FSS (Licensing & Registration of Food Businesses) Regulations, 2011, every FBO must have an FSMS plan and comply with Schedule 4 of the regulation, which outlines the general requirements for hygienic and sanitary practices. While GMP and GHP provide a foundation

level guidance on sanitation and care, HACCP augments this by requiring a systematic evaluation of all possible hazards specific to an operation and establishing monitored controls at critical points to manage significant risks. This creates a system that covers general hygiene and targets specific hazards.

2. Prescriptive Hygienic and Sanitary Practices

Schedule 4 of the FSSAI regulations prescribes that food establishments be located away from pollution sources, with layouts enabling unidirectional material flow to prevent cross-contamination. Internal surfaces—floors, walls, and ceilings—must be smooth, nonporous, and easy to clean, with effective drainage and screened openings to keep pests out. Equipment and containers in contact with food should be made of non-toxic, corrosion-resistant, food-grade materials, designed for easy cleaning and must be periodically calibrated for accuracy. Adequate potable water, proper waste disposal, clean and separate sanitation facilities, sufficient ventilation, and protected lighting are mandatory for maintaining safe operations. Additionally, personnel hygiene is emphasized through annual medical examinations, vaccinations, the use of clean protective clothing, and strict handwashing protocols, while prohibiting unhygienic behaviors such as smoking, spitting, or coughing in food handling areas.

3. Operational Controls Across the Food Chain

Raw materials must be procured from reliable suppliers and accompanied by a warranty (Form E), with all incoming materials inspected for spoilage, off odours, or microbial contamination. Storage areas should be properly designed to prevent cross contamination through segregation of raw, processed, packaging, and allergen containing materials. Stock rotation systems such as FIFO (First In, First Out) and FEFO (First Expire, First Out) must be implemented to maintain freshness and safety. Food Business Operators must employ a qualified professional in food technology, microbiology, or a related discipline to supervise production and ensure scientific accuracy. Standard Operating Procedures (SOPs) must be established for all stages, from handling to dispatch, to ensure process uniformity and compliance. Additionally, a documented pest control program, specifying target pests and control measures must be implemented. The facilities should be maintained in good condition to prevent pest entry and ensure that food materials are stored in pest proof containers and away from walls.

4. Surveillance, Monitoring, and Testing

Under the FSS (Licensing and Registration of Food Businesses) Regulations, 2011, Food Business Operators must conduct laboratory testing of their food products for relevant chemical and microbiological contaminants at least once every six months, either in house or through an NABL accredited laboratory, and upload the results to the Food Safety Compliance System (FoSCoS) portal within specified deadlines. To ensure consistency and reliability, FSSAI mandates the use of standardized procedures detailed in the 'Manual on Methods of Analysis for Microbiological Examination of Food and Water', which provides validated methods for detecting and enumerating pathogens such as *Salmonella*, *Listeria monocytogenes*, *E. coli*, *Bacillus cereus*, and *Vibrio cholerae*. Additionally, Appendix B of the regulations defines specific microbiological limits (m and M values) and sampling plans (n and c values) for various food categories, thereby setting consistent standards for compliance and ensuring reliable results across laboratories.

FSSAI implements a comprehensive food safety surveillance system to ensure market food safety through both passive surveillances, involving the receipt and analysis of reports from manufacturing units, and active surveillance via targeted sampling and testing. The data generated supports the identification of emerging risks, areas of concern, and informs risk management strategies. Concurrently, the field of microbiological testing is advancing through technological modernization, with a shift from manual methods to digital systems such as Laboratory Information Management Systems (LIMS) that enhance sample tracking, data accuracy, and traceability. The adoption of Rapid Microbiological Methods (RMMs) enables faster detection of contaminants compared to conventional culture-based techniques.

FSSAI's 'Food Safety on Wheels' uses mobile labs with rapid testing kits to detect adulterants and contaminants on-site, enhancing food safety monitoring at the grassroots level.

5. Emergency Response and Risk Management

FSSAI established the Food Safety Emergency Response (FSER) system under the FSS Act, 2006, to provide a coordinated mechanism for managing food safety emergencies. The FSER operates through three phases: the Alert Phase, involving identification and notification of incidents; the Action Phase, which may include product recalls, temporary bans, and public awareness campaigns and the Stand Down Phase, during which advisories are withdrawn once the situation is under control. The system is overseen by the Food Safety Coordination Committee (FSCC), comprising representatives from multiple ministries and organizations engaged in food safety. This response aligns with the modern Risk Analysis approach, instead of the unrealistic 'zero risk' goal to a science based evaluation of probability and severity of hazards, setting acceptable risk levels, and applying proportionate, risk based controls to improve the efficiency and effectiveness of the national food safety system.

Challenges in implementation

Despite this robust framework, challenges persist. A key challenge is promoting a culture of compliance, especially among highly established businesses that may be resistant to new food safety lessons. Furthermore, a vast majority of food poisoning cases go unreported, making it difficult to gather accurate data on the true incidence of foodborne illness. Experience has shown that the most effective way to improve safety levels is through targeted training of food handlers in their native languages, as they are the first line of defense against cross contamination. Key areas that consistently require focus are contamination control, cleaning protocols, and diligent record keeping.

Conclusion

The Food Safety and Standards Authority of India has developed a sophisticated system for controlling microbiological hazards in the food supply. By integrating legal mandates for FSMS, detailed hygienic practices under Schedule 4, and operational controls from farm to fork, FSSAI has established a strong preventive foundation. This is reinforced by a rigorous verification system of mandatory half yearly testing using standardized methods, active market surveillance, and a modern, risk-based emergency response framework. Even though there are still some difficulties in putting it into action, changing from a scattered, policy-based way of doing things to a unified, science-based system that matches the level of risk is a big improvement for keeping people healthy and safe. As technology continues to enhance testing and monitoring capabilities, FSSAI's framework is organised to become even more effective, ensuring the availability of safe and wholesome food for India's vast population.

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