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FOOD QUALITY AND FOOD SAFETY

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ABSTRACT
Food quality together with safety serves essential functions in maintaining public health and protecting consumers and managing worldwide food commerce. The chapter provides an extensive analysis of food safety challenges which cover biological and chemical as well as physical dangers that lead to food contamination. The text highlights the increasing rate of food-borne diseases caused by modern lifestyle changes and international food distribution networks and evolving microorganisms. The chapter examines the Food Safety and Standards Act of 2006 along with FSSAI and ISO and Codex Aliment Arius which serve as national and international regulatory bodies. Food safety management systems such as GMP, GHP and HACCP are analyzed to demonstrate how they maintain food safety throughout the entire food production process. The chapter concludes by demonstrating how food safety continues to grow in importance throughout industrialization and globalization which creates new opportunities for careers in food quality control and analysis and regulatory roles and research positions.

KEY WORDS
Food safety, Food quality, Food-borne illness, Contamination, Adulteration, HACCP, GMP, GHP, Food standards, FSSAI, ISO 9000, Codex Aliment Arius, Food Safety and Standards Act, 2006, Public health, Food safety management systems, Food inspection, Food legislation, Career in food safety, Quality control, Food adulteration tests.

INTRODUCTION

Food functions as an essential factor that combines with nutrition and health outcomes to determine national productivity levels. The protection of public health requires strict food safety monitoring since it needs safe nutritious food for consumption. Food-borne illnesses remain a major global health condition because people eat contaminated and counterfeit food products throughout the world. Health conditions reports always emphasize the need for food safety because unsafe food remains a constant risk.

The National Family Health Survey (NFHS-4) from 2015-16 reported that 9 lakh under-five children experienced acute diarrhea because of eating contaminated food and drinking unsafe water. The 2019–21 NFHS- 5 data indicates 7.7% of children under five experienced diarrhea during the two weeks before the survey.

The health conditions produce serious consequences that result in vulnerable deaths while damaging business and tourism sectors which generate economic losses and employment reduction and legal complications. Economic growth of nations faces significant challenges because of these combined effects. Food quality and safety control has become essential for world development because it protects public health and ensures sustainability.

STUDY FOCUS:

The Importance of Food Safety, Quality, and Regulation Ensuring the safety and quality of food has become a top priority in the modern food landscape, not only for households but also—and perhaps more importantly—for the industrial food processing, hospitality, packaging, and distribution sectors. The risks of contamination and quality compromise have greatly increased as mass-manufactured and convenience-based consumption patterns replace traditional home-processing methods. Food safety is now a significant national and international public health and economic issue, not just a personal one. Increased demand for packaged, functional, and ready-to-eat foods is a result of India's rapidly urbanizing population, rising incomes, and changing dietary preferences.

The food industry expanded along with it, but safety issues now involve scale. It is being driven by a number of interrelated factors:

- ✓ **Shifts in Lifestyle and Consumption**: Growing numbers of individuals dine out in cafes, restaurants, canteens, and street food stands. Food is prepared in bulk by multiple handlers in these establishments, raising the potential for microbial contamination. Ready foods are usually kept for extended periods of time in unsatisfactory refrigeration conditions or under unsanitary procedures.
- ✓ **Growth of the Processed Food Industry**: With packaged foods, from snacks to nutritional supplements, widely accessible, careful observation is necessary so as not to contaminate and maintain shelf safety.
- ✓ **Moving from traditional to industrial processing**: In the past, people ground and processed spices and oils by hand at home. Today, pre-packaged versions are common, especially in cities. This makes quality assurance an important public health issue, even for raw food ingredients.
- ✓ **Long supply chains and complicated logistics**: The time between making food and eating it is getting longer, especially in large-scale manufacturing and distribution. This necessitates rigorous risk management frameworks and ongoing quality oversight.
- ✓ **Emerging Microbial Threats and Antibiotic Resistance**: New food-borne microorganisms have emerged as a result of climatic changes, microbial evolution, increased international travel, and weakened immunity in some populations. Remarkably, within the last 25 to 30 years alone, almost half of all food-borne microbes have been identified. The majority of diseases still have no known cause, necessitating better research, more accurate diagnostic techniques, and global surveillance systems.

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
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- ✓ **Trade, Regulation, and International Standards**: India has vowed to respect international food safety and quality standards as a World Trade Organization (WTO) member. As a result, strict safety regulations have had to be applied to both imported and exported foods. Indian manufacturers are now required to undergo effective testing, obtain certification, and adhere to international standards such as ISO 22000 and Codex AlimentArius.

Environmental Pollution: Chemical residues from pesticides, contaminants in soil and water, and harmful food additives like artificial preservatives, flavor enhancers, and coloring agents are just a few of the pollutants that food is exposed to today. As a result, regular food testing for toxins and nutrients has become essential.

The Food Safety and Standards Act (FSSA) of 2006 functions as a legal framework which the Indian government introduced during the year 2006 to improve food regulation standards. The historic legislation consolidated various foods-related laws into one, unified set. The Food Safety and Standards Authority of India (FSSAI) was created through the Act. Its mandate is to develop science-based standards for food, control manufacturing processes and distribution practices, and guarantee that consumers are assured of safe and healthy food. The FSSA places its focus on preventative health measures because it aims to reduce food safety risks across the entire supply chain through its implementation of HACCP and GMP and GHP standards.

AIM OF THE RESEARCH PAPER

This Research Paper investigates how food safety and quality play essential roles in public health and economic growth and international trade with specific reference to India. The study analyzes the main hazards in food and analyzes national and international food safety standards while assessing the Food Safety and Standards Act (FSSA) 2006 and examines how HACCP, GMP and GHP systems protect consumers from food safety risks. The paper presents an investigation into new food safety obstacles while demonstrating the growing career potential and research possibilities in this essential domain.

BASIC CONCEPTS

A proper understanding of food safety basics helps to effectively handle food-related dangers. The evaluation of food safety depends on first establishing precise meanings for food safety together with toxicity and hazard.

- **Food Safety**

The term food safety defines the condition which makes food safe for human eating based on its intended purpose. The safety measures used during production and processing and storage and consumption stages prevent food contamination which protects consumers from harm.

- **Toxicity and Hazard**
  - ✓ **Toxicity**: - The ability of a substance to produce damage or injury exists under particular conditions known as toxicity. Certain substances possess this characteristic which exists naturally in food products.

  - ✓ **Hazard**: - Hazard is the likelihood that a substance will become harmful if used improperly or in excess. Physical, biological, and chemical components all pose unique risks to consumers when it comes to food safety.

Hazard Types

1. **Physical Hazard: -** Physical Risks Unwanted physical materials present in food pose a risk of harm or disease. The following items are examples of physical hazards, which are foreign substances that shouldn't be present in food: Stones ,Wood fragments, Hair, Feathers, Metal particles (nails, nuts, bolts), Jewelry, Cigarette butts, Matchsticks, Jute fibers, Bone fragments, Parts of insects or pests .

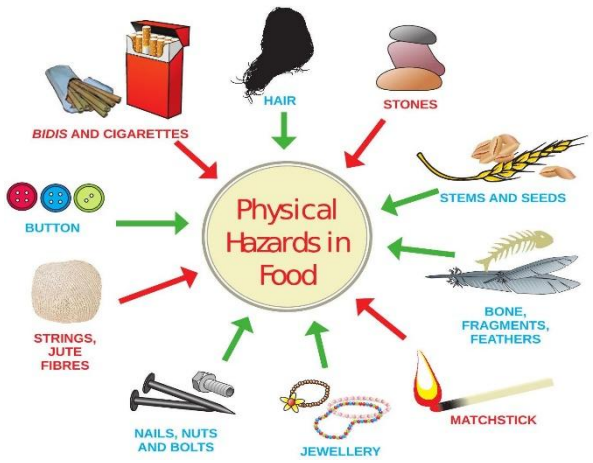

Fig:- Physical Hazards In Foods

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
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Vol. 35 Issue 2, 2025, Pages: 2181-2187

Food products become contaminated when processing and packaging stages combine with storage periods as well as handling activities.

2. **Chemical Hazards :-** Chemical hazards contain dangerous substances together with residues which may be deliberately introduced or accidentally introduced into food products. They include: Pesticide residues**,** Cleaning chemicals **,**Toxic metals**,** Veterinary drug residues**,** Food adulterants**,** Unauthorized food additives**,** Excessive levels of permitted additives

Detection of these substances requires scientific testing because they produce toxic effects.

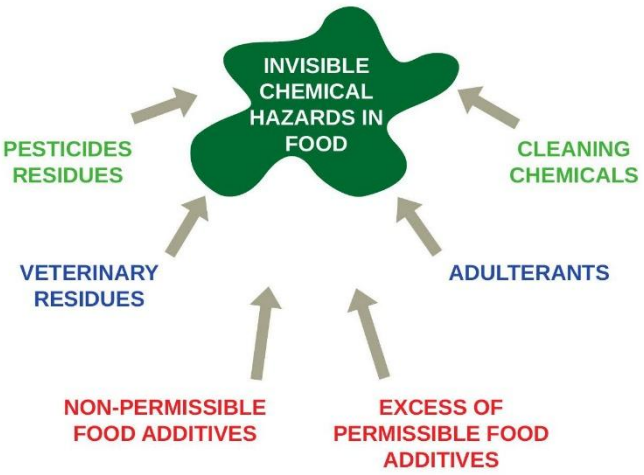


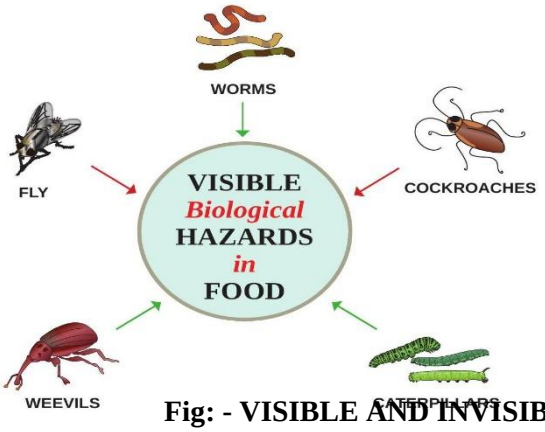
Fig:- Chemical Hazards In Foods

3. **Biological Hazards**

The living organisms and their by-products represent biological hazards which represent the leading cause of food-borne illnesses. They are divided into two categories:

a. Visible Biological Hazards: Biological hazards which are visible include pests such as flies and weevils as well as cockroaches together with caterpillars and worms.

b. Invisible (Microbiological) Hazards: Bacteria, Viruses, Protozoa, Moulds and Yeasts.



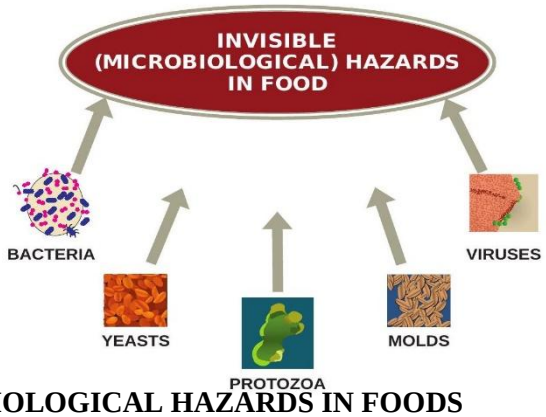


Fig: - VISIBLE AND INVISIBLE BIOLOGICAL HAZARDS IN FOODS

Food Infections and **Food Intoxications** occur when microorganisms contaminate food.

- **Food Infection**: - The consumption of live disease-causing organisms such as Salmonella leads to food infections because these microbes multiply inside the human body causing diarrhea and fever. The main infection sources are unpasteurized milk and eggs and meat which lack proper cleaning procedures.
- **Food intoxication:** - Food poisoning occurs because microbial toxins develop in food even though cooking eliminates the bacteria. Staphylococcus aureus produces toxins that persist after cooking which then results in illness. These toxins remain undetected by human taste and smell senses.
- **Parasite**: - People who consume pork contaminated with tapeworms become highly vulnerable to foodborne infections.

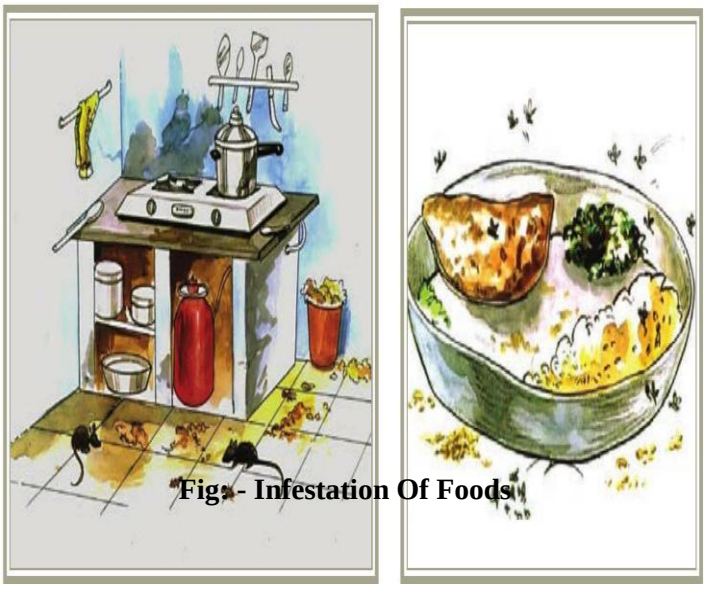


Fig:- Infestation Of Foods

Biological hazards represent the primary reason behind food-borne illnesses across the world among all hazard types. New pathogens emerge continuously because of microbial mutations along with global food trade and other factors which lead to improved safety practices.

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
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Vol. 35 Issue 2, 2025, Pages: 2181-2187

EMERGING PATHOGEN RISKS

Multiple elements work together to generate new pathogens:

- The immune system changes in people because of aging or nutritional deficiencies or medical conditions.
- People now interact more frequently with animals which increase pathogen transmission risks.
- Microbes undergo genetic alterations which produce new strains.
- The methods of producing food on an industrial scale along with worldwide food distribution networks.
- People now choose different foods and eating patterns.
- The combination of environmental deterioration and climate change results in negative effects.

The rising pathogens that cause food-borne illnesses include Norovirus together with Rotavirus and Hepatitis E which cause many current cases of food-borne illnesses.

CONTAMINATION VS. ADULTERATION

Food safety depends on understanding how contamination differs from adulteration.

- ✓ **Contamination** occurs when food contains unwanted substances unintentionally including dirt microorganisms and chemicals which enter the food during any stage of the processing sequence.
- ✓ **Adulteration** represents the practice of reducing food quality through intentional or unintentional methods which involve incorporating inferior elements and subtracting important components from the product. The following practices are included in this category:
  - Food quality diminishes through the use of harmful materials and low-quality components.
  - The elimination of vital ingredients from food products.
  - Contaminants can enter food products throughout the production process as well as during storage and transportation stages.
- ✓ **Adulterants**:- Any substance which people use to decrease food quality while making it dangerous for human consumption is considered an **adulterant**.

FOOD QUALITY

The complete set of characteristics which determine a food product's value to consumers constitutes food quality. The attributes consist of two types:

a) **Negative factors**: Spoilage, contamination, adulteration, presence of hazards
b) **Positive traits**: Nutritional value, flavor, texture, color, appearance, and freshness

The safety of food constitutes an essential foundation which food quality cannot exist without. Quality includes hygiene together with sensory appeal along with nutrition and social acceptability.

Food Standards exist as international rules which national authorities use to guarantee food products meet both safety requirements and quality standards. These standards cover each phase of the food supply chain starting at raw material acquisition until the final stage of packaging and service delivery.

Technology in Food Safety: From Farm to Fork

Food safety management is now in a new state due to advancements in technology which allow real-time monitoring along with improved operational effectiveness. Technologies transforming food safety include:

a) **Internet of Things (IoT) Sensors**: IoT sensors are installed all along the food supply chain to monitor levels of temperature as well as humidity and other important factors that ensure food safety while in transit and storage. The integration of IoT technology with refrigerators installed in trucks and warehouses sends real-time alerts when levels of temperature become unsafe.
b) **Blockchain Technology**: Blockchain technology makes an immutable digital record which follows food products from farm to consumer plate. The whole process from harvest to store storage and transport is documented to have total transparency and traceability. Rapid recalls are now feasible since the origin of contamination can be traced that prevents large-scale illness outbreaks.
c) **Artificial Intelligence (AI)**: AI programs today function to predict food safety threats based on their analysis of vast food production data in conjunction with inspection data. By analyzing patterns of contamination AI-driven models help food manufacturers come up with better quality control processes.
d) **Biosensors:** The sensors employ sophisticated technology to sense microbial contamination in food products with accurate precision that assists in reducing the requirement for traditional testing methods that are time-consuming and extremely expensive.

Key Requirements for Food Service Providers

To achieve food quality and safety the entire production and service chain must establish these recommended procedures:

1. Use high-quality raw materials and clean water.
2. Maintain cleanliness in the kitchen, storage, equipment, and service areas.
3. Store food at safe and appropriate temperatures.
4. Practice personal hygiene and food sanitation.
5. Follow proper service procedures and handling protocols.

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
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SCOPE

The rapid expansion of India's food processing industry contributes to approximately 26 percent of GDP making food safety and quality key concerns. The Food Safety and Standards Act (FSSA), 2006 substituted conventional food laws with a preventive risk-based model that ensures safe and wholesome food at the end of the entire supply chain.

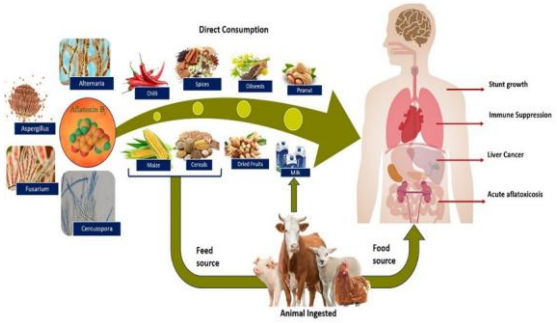
The growing significance of food safety has provided new career opportunities in food analysis and microbiology in addition to quality control and HACCP auditing and regulatory compliance roles. Experts have career opportunities in FSSAI and Agmark and BIS as well as private industries and laboratories and consultancy agencies. The food safety industry now facilitates entrepreneurship by way of education and testing services.

The sector offers increasing job opportunities as well as the potential for innovation and beneficial public health impacts.

CASES OF INDIA (FOOD)

1:- Case: Aflatoxin Outbreak in Karnataka (2021) – Climate Impact on Food

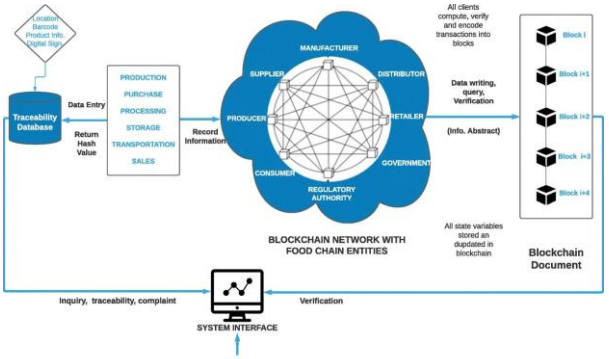
The year 2021 saw severe aflatoxin contamination in groundnuts together with maize across several North Karnataka regions because fungi produce toxins under hot and humid conditions. The increase in aflatoxin contamination occurred because of the unusual weather conditions combined with poor storage techniques after harvest.



The consumption of aflatoxins causes liver cancer together with developmental problems which affect children. The case showed that climate-related weather changes promote mycotoxin development in food crops which creates health risks and export restrictions.

2:- Case: ITC's Blockchain Pilot in Andhra Pradesh (2022) – Tech in Food Safety

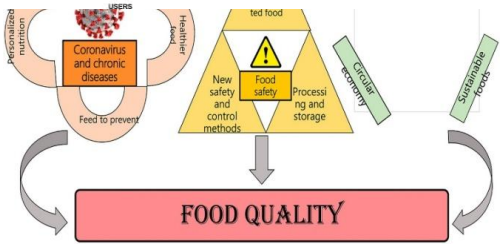
The agribusiness giant ITC started using blockchain technology to trace its spice supply chain across Andhra Pradesh. All stakeholders including farmers processors and buyers obtained secure access to information which verified the origin along with the quality and processing details of chili products.



The project cut down supply chain fraud while achieving better adherence to EU safety standards and boosting export consumer trust. The project stands as a concrete demonstration showing how blockchain technology enhances farm-to-fork food traceability.

3:- Case: COVID-19 Lockdown and Swiggy's Hygiene Badges (2020)

In the heart of the COVID-19 pandemic Swiggy launched a rating system for its partner restaurants to assess hygiene standards. The app displayed restaurants only after they implemented contactless delivery and kitchen sanitation protocols and trained their food handlers.



The restaurant evaluation teams checked whether staff members wore masks and washed their hands along with having their temperatures measured. The program established trust among consumers while protecting food delivery safety and created a model for technology-based pandemic-proof food delivery systems.

4:- Case: Consumers require enhanced understanding of food safety principles according to the analysis of the 2015 Maggi Noodles case.

The Food Safety and Standards Authority of India (FSSAI) implemented a nationwide ban of Nestlé's Maggi instant noodles during 2015 because laboratory tests showed both dangerous lead contamination and the presence of monosodium glutamate (MSG). The massive market presence of the brand demonstrated how most customers lacked knowledge about food additives and harmful substances. The case revealed that most consumers lacked knowledge about food labels together with nutritional data and safety standards. The nationwide debate about food rules and ingredient transparency began when Maggi obtained permission to return to shelves and consumers across the country started evaluating the importance of food choices.

LITERATURE REVIEW

Academic and regulatory bodies pay increasing attention to food quality and safety because of complex global food systems and consumer requirements for secure and nutritious food with traceability. The literature shows that food safety evolved from being a household concern into a system-wide element that affects public health together with economic policy and international trade and technological innovation.

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- **Food Safety and Public Health**

Numerous scientific investigations demonstrate that food safety measures serve as a fundamental element for maintaining public health. According to the World Health Organization (WHO), each year 600 million cases of food-borne illness occur due to contaminated food, resulting in 420,000 fatalities globally (WHO, 2020).

Food-borne illnesses represent a major health issue for India especially affecting children who are younger than five years old. During NFHS-4 (2015–16) 9 lakh children experienced acute diarrhea because of contaminated food and water. According to NFHS-5 (2019–21) seven point seven percent of children under five years old experienced diarrhea within two weeks before the survey. These statistics demonstrate that unsafe food creates direct health risks which lead to death alongside sickness and nutritional deficiencies in at-risk groups.

- **Hazards in Food and the Need for Control Systems**

According to **Unnevehr and Hoffmann (2015)** food hazards exist as physical and chemical and biological categories in literature. Food-borne illnesses worldwide primarily result from biological hazards which include bacteria viruses and parasites. The risks have increased because of the resistant microbial strains which appear from industrial food production combined with globalization and climate change. The adaptive nature of Salmonella together with Listeria and E. coli requires enhanced monitoring and diagnostic methods.

International organizations like Codex Alimentarius and ISO 22000 together with FSSAI and other national authorities have developed risk-based food safety frameworks to tackle these threats. Food safety management systems including HACCP along with GMP and GHP have become essential elements for domestic and export markets.

- **Regulatory Frameworks and the FSSA, 2006**

The Food Safety and Standards Act (FSSA) became law in 2006 to restructure India's food regulatory framework. Food regulations operated through multiple agencies and ministries which functioned independently before the Act became effective. Through the FSSA the Food Safety and Standards Authority of India (FSSAI) was established as the primary regulatory authority to combine existing regulations. The Act defines safety standards together with scientific measures and consumer protection protocols. According to Bhat & Rao (2018) research the Act enables better enforcement of safety compliance within the Indian food industry.

- **Technology in Food Safety**

Multiple recent studies examine how food safety receives a transformative impact from technological developments. ITC's Andhra Pradesh blockchain implementation enables complete food product tracking from agricultural production to consumer delivery which boosts confidence and lowers fraud risks. Real-time monitoring of food storage and transport conditions becomes possible through Internet of Things (IoT) devices and biosensors. The food industry applies Artificial Intelligence (AI) for contamination risk prediction models. The implemented technologies both optimize operational processes and enhance compliance with food safety standards in extensive supply chains.

- **Consumer Awareness and Behavior**

The research consistently emphasizes how consumers lack sufficient knowledge about food safety practices. In 2015 the Maggi noodles incident demonstrated that many people did not understand food additives such as MSG and hazardous substances including lead. Regulatory agencies responded quickly but public knowledge about labeling practices as well as adulteration and food testing remained deficient. According to researchers food safety education needs to be part of school programs and public initiatives particularly targeting rural areas and disadvantaged communities (Deshpande, 2020).

- **Environmental and Climate Concerns**

The safety of food continues to face increasing risks because of climate change factors. Research shows that unpredictable weather events including excessive rainfall together with elevated humidity levels help mycotoxins develop within crops. The 2021 aflatoxin outbreak in Karnataka demonstrates how maize and groundnuts became contaminated due to improper storage combined with shifting weather patterns. The occurrence of these events demonstrates why food systems must adapt to climate conditions while developing early warning systems.

- **Post-Pandemic Food Safety Innovations**

The pandemic period of COVID-19 sped up digital transformation alongside sanitary methods for food processing operations. Food delivery platform Swiggy established hygiene certification procedures together with contactless food delivery methods. Research shows the pandemic created an everlasting modification to how consumers expect transparency and cleanliness in food service operations according to Khurana et al. (2021).

- **Career and Research Opportunities**

Food safety regulation advancement together with technological progress has increased the need for professionals trained in quality control and auditing and microbiology and policy development fields. Food safety exists as an interdisciplinary field that provides career paths in scientific disciplines together with legal practice and public health and entrepreneurial ventures. The recruitment of specialists continues at FSSAI and Agmark and BIS and private laboratories.

RESEARCH METHODOLOGY

The research paper uses descriptive and analytical methods to study the relationship between food quality and food safety in Indian contexts. The research methodology depends on analyzing existing data through reviewing literature together with reports and case studies to establish conclusions and present important findings.

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1. Nature of the Study

The research focuses on qualitative methods to study food safety beyond its regulatory status as it impacts public health along with technological requirements and socio-economic effects. The research conducted includes case-based analysis which shows how theoretical concepts apply to actual food safety situations.

2. Data Collection Method

The research study depends on information obtained from secondary sources. The materials reviewed include:

- **National health surveys like NFHS-4 (2015–16) and NFHS-5 (2019–21)**.
- Reports and guidelines from FSSAI, Codex Alimentarius, and ISO.
- Articles and advisories published by the World Health Organization (WHO).
- Research papers and academic journals on food safety systems like HACCP, GMP, and GHP.
- News reports on major food safety incidents (e.g., the Maggi noodles case, aflatoxin contamination).
- Industry innovations documented in corporate case studies (e.g., ITC blockchain pilot, Swiggy's hygiene badge system).

3. Research Objectives

The methodology provides support to achieve the following research objectives:

- The research aims to determine the effects of food safety on public health conditions within India
- The research investigates the different levels and dangers of food-related hazards.
- The research evaluates legal and regulatory systems with focus on Food Safety and Standards Act 2006
- This research studies the implementation of current food safety management systems (HACCP GHP GMP)
- The study investigates how technological advancements including IoT and blockchain together with AI affect the management of food safety
- The study presents actual Indian food safety incidents and draws learning points from these cases.
- The research investigates the employment prospects which exist inside food safety industry

4. Data Analysis Method

- The research employs thematic content analysis as its data analysis method. The researcher examined all data sources to identify main themes through content categorization which included the following areas:
- The analysis includes real-life case studies that demonstrate these themes through practical instances.

5. Limitations of the Study

The research study aims to deliver extensive knowledge but contains several restrictions:

I. The research is limited to secondary data; no primary data (surveys, interviews) has been collected.
II. Certain regulatory and technical information remains inaccessible through public sources.
III. The study focuses mainly on Indian geography yet incorporates international data for comparative purposes.

CONCLUSION

Food quality together with safety serve fundamental functions for maintaining public health and economic systems along with international commerce. The rising incidence of food-related illnesses together with widespread packaged food consumption requires strict safety protocols alongside enhanced consumer education.The Food Safety and Standards Act (FSSA) of 2006 together with HACCP, GMP and GHP systems establish a robust framework to guarantee food safety standards. The integration of Internet of Things (IoT), Artificial Intelligence (AI) and blockchain technologies enables new methods for product monitoring and tracing.The Maggi ban alongside the aflatoxin outbreak and Swiggy's hygiene badges show both difficulties and improvements through case studies. The field also offers expanding career and entrepreneurial opportunities. Safe food production exists as a group duty which requires efforts from regulatory organizations and industrial entities together with individual consumers.

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