HNSEC - 02

FOOD SAFETY AND STANDARDS

उ० प्र० राजर्षि टण्डन
मुक्त विश्वविद्यालय, प्रयागराज

HNSEC-02 FOOD SAFETY AND STANDARDS

COURSE CONTENT

UTTAR PRADESH RAJARSHI TANDON OPEN UNIVERSITY
HNSEC-02 FOOD SAFETY AND STANDARDS

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UNIT - I

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Overview

Block 1. Introduction and Significance of Toxicology in Food

Unit I :Xenobiotics Toxicologically relevant principles of the cell and molecular biology

This unit provides a comprehensive exploration of the dynamics and kinetics of xenobiotics, specifically focusing on environmental pollutants and their entry into the food chain. Xenobiotics are foreign substances introduced into the environment through human activities, such as industrial processes and agricultural practices, which can have adverse effects on ecological systems and human health. The unit begins by elucidating the pathways through which environmental pollutants are released into the environment and subsequently enter the food chain. It highlights the primary sources of pollution, including industrial discharges, agricultural runoffs, and atmospheric deposition, and emphasizes the critical role of bioaccumulation and biomagnification in the transfer of these pollutants through various trophic levels. Furthermore, the unit delves into the kinetics of xenobiotics, examining their absorption, distribution, metabolism, and excretion (ADME) within organisms. It explores the factors influencing the bioavailability and bioaccumulation of pollutants, such as physicochemical properties, environmental conditions, and species-specific characteristics. Moreover, the unit discusses the toxicological implications of xenobiotics in the food chain, addressing their potential impact on ecosystem stability and human health. It highlights the importance of risk assessment and monitoring programs to mitigate the detrimental effects of environmental pollutants.

Unit II: Introduction and significance of food toxicology

Food toxicology is a critical field of study that focuses on the detection, analysis, and evaluation of toxic substances present in food and their potential effects on human health. This abstract provides an introduction to food toxicology and highlights its significance in ensuring food safety and public health. The introduction outlines the fundamental principles of food toxicology, including the sources of food contaminants, the mechanisms of toxicity, and the routes of exposure. It emphasizes the interdisciplinary nature of the field, involving aspects of chemistry, biology, pharmacology, and risk assessment. The significance of food toxicology lies in its ability to identify and assess potential hazards in food, ranging from naturally occurring toxins to chemical contaminants and food additives. By understanding the toxicological properties of these substances, scientists and regulatory bodies can establish safe limits, develop effective control measures, and enforce stringent regulations to protect consumers from harmful effects. Ultimately, the importance of food toxicology cannot be overstated as it contributes to the development of evidence-based food safety guidelines, supports risk assessment and management, and plays a crucial role in safeguarding public health.

BLOCK-2 Food Safety Laws and Standards

Unit III: Microbial and chemical toxins Microbial toxins and food intoxication

This unit delves into the fascinating field of microbial toxins and their role in food intoxications. Microorganisms, such as bacteria, fungi, and viruses, have developed various mechanisms to produce toxins that can cause detrimental effects on human health when ingested through contaminated food. This overview focuses on the diverse types of microbial toxins encountered in foodborne illnesses, shedding light on their characteristics, sources, and modes of action.

Unit IV: Food Safety Laws and Standards

4.1 International Standards and Guidelines:

Provides an overview of international organizations, such as ISO mark for vegetarian and non-vegetarian foods, and their role in setting global food safety standards. Discusses key international standards and guidelines, such as the Codex Alimentarius Commission and its impact on national regulations.

4.2 National Food Safety Legislation:

Examines the role of national governments in establishing and enforcing food safety regulations like Food safety laws and standards: FSSAI, FPO, ISI, Agmark.

Provides examples of key legislation in various countries, such as the Food Safety Modernization Act (FSMA) in the United States and the Food Safety and Standards Act in India.

Unit-I

Xenobiotics Toxicologically relevant principles of the cell and molecular biology

1.1 Introduction

The term "xenobiotics" refers to substances that are found in biologic systems but are not native to them. Environmental and occupational exposures to these xenobiotics include pesticides (DBCP, malathion, and atrazine), water pollutants (such dibutyl phthalates, or DBPs), persistent organochlorine pollutants, polychlorinated biphenyl, and phthalates. Male fertility is negatively impacted by the estrogenic actions of many xenobiotics. Other environmental factors that may also affect men's fertility include heat, radiation, hypoxia, intense physical activity, and psychological stress.

Definition:A substance that is alien to the body is known as a xenobiotic (literally, "stranger").
Xenobiotics can cause a range of biological effects, including as cancer, toxicity, immunological reactions, and pharmacological reactions.

Xenobiotics can be either Exogeneous or Endogenous.

Exogeneous are foreign substances that the body does not ordinarily absorb or use, but they enter through food, medications, or environmental substances that are breathed. Examples include chemicals that cause cancer, pollution, food additives, drugs, and insecticides.

Endogenous chemicals act similarly to exogenous xenobiotics, although they are not foreign compounds. The body produces them as metabolites of different bodily activities or synthesizes them itself. Examples include steroids, bile acids, eicosanoids, bilirubin, and certain fatty acids.

Dynamics and kinetics of xenobiotics

The term "xenobiotic" refers to substances that are external to an organism's regular metabolism and to which it is exposed. Many xenobiotics would accumulate to dangerous levels in the absence of metabolism. Energy, cofactors, and enzymes are necessary for the majority of metabolic processes that take place inside the cell. Phase I, phase II, and transporter enzymes are the three categories of xenobiotic-metabolizing enzymes. Phase I enzymes, which increase the polarity of xenobiotics and give sites for conjugation processes, frequently metabolize lipophilic xenobiotics first. Conjugating enzymes, phase II enzymes can interact directly with xenobiotics but more frequently with the metabolites that phase I enzymes create. These more polar metabolites are removed by both active and passive transport. The majority of xenobiotics are eliminated by a variety of enzymes and processes.

The majority of a person's metabolic processes are often determined by the interplay among chemical concentrations, enzyme amount and affinity, and cofactor availability.

Dynamics and kinetics of xenobiotics refer to the processes by which foreign compounds, known as xenobiotics, interact with the body and undergo various transformations. Xenobiotics can include a wide range of substances, such as drugs, environmental pollutants, and chemicals. Understanding the dynamics and kinetics of xenobiotics is crucial for assessing their effects on biological systems and predicting their fate in the body.

1.2.1 Dynamics of Xenobiotics: The dynamics of xenobiotics primarily involve their Absorption, Distribution, Metabolism, and Excretion (ADME) within the body. Let's explore each of these processes in detail:

1. Absorption: Absorption refers to the entry of xenobiotics into the body. It can occur through different routes, such as oral ingestion, inhalation, dermal contact, or injection. The characteristics of the xenobiotic, such as its solubility, size, and charge, influence its absorption. The gastrointestinal tract, lungs, and skin are major sites of absorption for xenobiotics.
2. Distribution: After absorption, xenobiotics are distributed throughout the body via the bloodstream. Their distribution is influenced by factors such as blood flow, tissue permeability, and protein binding. Xenobiotics can accumulate in specific organs or tissues, depending on their physicochemical properties. For example, lipophilic compounds tend to accumulate in fatty tissues.
3. Metabolism: Xenobiotics undergo various metabolic reactions in the body, primarily in the liver, to facilitate their elimination. The metabolism of xenobiotics involves two main phases: Phase I reactions and Phase II reactions. In Phase I reactions, xenobiotics are often converted into more polar and reactive metabolites through processes such as oxidation, reduction, and hydrolysis. Phase II reactions involve the conjugation of xenobiotic metabolites with endogenous compounds, such as glucuronic acid, sulfate, or glutathione, making them more water-soluble and facilitating their excretion.

4. Excretion: Excretion is the process by which xenobiotics and their metabolites are eliminated from the body. The major routes of excretion include renal excretion (urine), biliary excretion (feces), and pulmonary excretion (breath). Renal excretion is particularly important for water-soluble compounds, while lipophilic compounds are often excreted via the bile into the feces. Some xenobiotics can also be eliminated directly through sweat, saliva, or breast milk.

1.2.2 Kinetics of Xenobiotics: The kinetics of xenobiotics involve the study of their rates of absorption, distribution, metabolism, and excretion. It encompasses various parameters that quantify the processes involved. Here are some key concepts related to xenobiotic kinetics:

1. Absorption kinetics: Absorption kinetics describes the rate and extent to which a xenobiotic is absorbed into the body. It involves parameters such as absorption rate constants, bioavailability, and the time taken to reach peak plasma concentration after administration.
2. Distribution kinetics: Distribution kinetics focuses on how xenobiotics are distributed within the body. Parameters such as volume of distribution, tissue-to-plasma concentration ratios, and protein binding influence the distribution kinetics. These parameters determine the concentration gradient between different compartments and the equilibration rates.
3. Metabolic kinetics: Metabolic kinetics examines the rate at which xenobiotics are metabolized in the body. It involves determining the metabolic rate constants, enzyme kinetics, and the formation and elimination of metabolites. Understanding metabolic kinetics is crucial for assessing the potential for drug-drug interactions and the generation of toxic metabolites.
4. Excretion kinetics: Excretion kinetics involves studying the elimination of xenobiotics from the body. Parameters such as clearance, elimination rate constants, and half-life are used to quantify excretion kinetics. These parameters provide insights into the rate at which xenobiotics are eliminated and help determine appropriate dosage regimens.

Metabolism of Xenobiotics

There are two stages to xenobiotic metabolism. In phase 1, hydroxylation is the main reaction that takes place. A variety of other reactions occur in addition to hydroxylation, such as-

*Deamination:*Deamination is the process by which an amine group (-NH2) is taken out of a xenobiotic molecule, thereby "de-aminating" it and making it more polar and ready for more metabolism in phase I of xenobiotic metabolism.

Dehalogenation: The enzymatic removal of a halogen atom (such as chlorine, bromine, or iodine) from a xenobiotic is known as dehalogenation, and it occurs during phase I of xenobiotic metabolism. The "dehalogenases" that are mostly present in bacteria and certain other microorganisms are the enzymes that frequently facilitate it.

Desulfuration: It is the process by which a sulfur atom is extracted from a xenobiotic molecule during phase I of xenobiotic metabolism. Enzymes like cytochrome P450s usually catalyze this process, which makes the molecule more polar and facilitates its excretion from the body.

Epoxidation: It is the term used to describe the process by which a cytochrome P450 enzyme forms a three-member cyclic epoxide ring by adding an oxygen atom to a double bond in a xenobiotic molecule during phase I of xenobiotic metabolism. Usually regarded as a detoxifying step, this epoxide intermediate is highly reactive and can be further broken down by the enzyme epoxide hydrolase to generate a 1,2-diol. This process is very crucial for the metabolism of some medicines, contaminants, peroxygenation, etc.

Reduction: Epoxidation is the process by which a xenobiotic molecule acquires an electron during phase I of xenobiotic metabolism. Enzymes such as cytochrome P450s (CYPs) catalyze it, producing a more polar and maybe less poisonous chemical that can be further processed for the body to eliminate.

In phase 2, particular enzymes transform the hydroxylated or other molecules generated in phase 1 into a variety of polar metabolites through methylation, conjugation with glutathione, glutaric acid, sulfate, acetate, or certain amino acids.

Biotransformation/ Detoxification Reactions

Detoxification/biotransformation reactions are the collective term for all biochemical processes that change foreign, poisonous, and water-insoluble molecules into nontoxic, water-soluble, and excretable forms. The two stages of xenobiotic metabolism work together to make the drugs more soluble in water (polarity), which facilitates their removal from the body. These reactions are known as oxidation reactions because they can sometimes instead make a foreign molecule more hazardous.

Effects of Xenobiotics

- A xenobiotic's metabolism may cause cancer, immunologic harm, or cell injury.
- Cytotoxicity, or cell damage, can be so severe as to cause cell death.
- These macromolecular targets consist of proteins, RNA, and DNA.
- It is possible for a xenobiotic's reactive species to attach to a protein and change its antigenicity.

- ❖ The resultant antibodies have the potential to cause harm to the cell through a variety of immunologic pathways that significantly disrupt regular cellular metabolic functions.
- ❖ In chemical carcinogenesis, reactions between DNA and activated species of chemical carcinogens are crucial.
- ❖ Certain substances, including benzo[α]pyrene, are referred to as indirect carcinogens because they must be activated by monooxygenases in the endoplasmic reticulum in order to cause cancer.
- ❖ Epoxides are the byproducts of specific monooxygenases' reactions with specific procarcinogen substrates.
- ❖ Epoxides are extremely reactive substances that can cause cancer, mutagenesis, or both.
- ❖ Epoxide hydrolase, which functions similarly to cytochrome P450, transforms these substances into dihydrodiols that are significantly less reactive.

Drugs, food additives, and environmental contaminants are examples of xenobiotics—chemical substances that are not naturally present in the body. The metabolism of xenobiotics occurs in two stages. A number of monooxygenases, commonly referred to as the cytochrome P450s, catalyze the primary reaction of phase 1, which is hydroxylate. The hydroxylated species undergo conjugation with a range of hydrophilic substances, including glutathione, sulfate, and glucuronic acid, in phase 2. These two processes work together to transform lipophilic substances into water-soluble substances that the body can get rid of. Numerous physiological consequences, such as pharmacologic reactions, toxicity, immunologic reactions, and cancer, can be caused by xenobiotics.

Overall, dynamics and kinetics of xenobiotics play a vital role in understanding their behavior in the body, their pharmacological effects, and potential toxicities. They provide valuable information for drug development, dose optimization, and risk assessment of environmental pollutants.

1.3 Environmental pollutants entering in the food chain

Depending on the chemical, its physical characteristics, its use, and the source or mechanism of contamination, chemicals can contaminate food in a variety of ways. Chemicals from agriculture or industry have been the organic materials that have tainted food. The only agricultural chemicals that are known to pollute the environment in food are pesticides. When a pesticide is found in foods for which its use or application has not been authorized, it constitutes an environmental contamination. When pesticides are manufactured or applied nearby, or when residues are carried through the environment, livestock, poultry, and fish may become polluted.

Additional causes of environmental pollution include improperly fumigated railroad carriages, trucks, ships, or storage facilities used for the transportation or storage of animal feed and human food. Pesticides are sprayed or fumigated inside, and if the interior is not well ventilated, the food or feed becomes contaminated. Sludges, gasses, and liquid effluents of various chemical complexity are produced during the production of organic compounds. Despite federal legislation and related disposal requirements, organic wastes cannot be kept out of the environment by the conventional waste disposal methods (landfills, incineration, and sewage systems). The soil, the atmosphere, and surface or ground water are some of the pathways.

There are various ways that metals can be discharged into the environment. Dust and gasses are released into the atmosphere during the mining and refining processes. As waste products, metallic salts produced during the recovery and refining processes may leak into surface and ground water. There is also a risk of food contamination when sewage sludge is applied as fertilizer on agricultural land. Crops grown on treated soil may absorb trace metals from the sludge. The trace metal in sludge that causes the most worry at the moment is cadmium. Natural radiation is one of three sources of radioactivity in food. released from pasta, cheese, and fish Nuclear reactor and processing plant operations, fallout from nuclear weapons tests, fish, eggs, and baked goods.

Deposition of airborne particles on vegetation or soil is the main way that food gets polluted. The chemical and physical characteristics of the radionuclide, as well as whether it is absorbed and digested by plants or animals, dictate its future course. When mining and processing ores that contain radioactive materials, natural radioactivity may become an issue. The radionuclides may be the focus of the trash or products. Slags from phosphorus manufacture, phosphate rock waste, and uranium tailings are a few examples of this. When radium dissolves in groundwater and is absorbed by plant roots, it may make its way into the food chain.

We have been using packaging materials, especially plastics, to carry and preserve food more and more in recent years. These substances are not inert and have the potential to contaminate food and beverages since they can release a variety of chemicals into them. Known as "migrants," these substances include phthalate plasticizers, which have been found in bottled water. greater levels of contamination were associated with factors including greater storage temperatures and longer periods of contact with the packaging; however, a health risk assessment revealed that the harm to consumers was minimal.Due to the proliferation of electrical devices in modern culture, electronic garbage, or "e-waste," has grown to be a significant issue.

When such products are processed improperly, such as by incomplete combustion, a number of pollutants discussed above are released, such as metals/metalloids, PCBs, dioxins/furans (PCDD/Fs), PAHs, and PBDEs. Additionally, food and drinking water might become contaminated by these devices.

The health of humans and the environment are seriously threatened by environmental contaminants getting into the food chain. These pollutants, also known as contaminants, can come from a variety of sources, including trash disposal, industrial operations, agricultural practices, and natural processes. They may eventually find their way into the food we eat after building up in the environment. These contaminants may come from a variety of sources, such as inappropriate waste disposal, industrial operations, and agricultural practices. They can contaminate soil, water, and the atmosphere after being discharged into the environment, and eventually they will make their way into the food we eat.

There are several types of environmental pollutants that can enter the food chain:

1. Pesticides and herbicides: These chemicals are widely used in agriculture to control pests, weeds, and diseases. They can accumulate in soil and water, and some are persistent, meaning they remain in the environment for long periods. When crops are sprayed with pesticides or herbicides, residues can remain on the surface or penetrate the plant tissues, leading to direct consumption by humans or animals.
2. Heavy metals: Heavy metals such as lead, mercury, cadmium, and arsenic are naturally occurring elements but can also be released into the environment through industrial activities, mining, and the burning of fossil fuels. These metals can contaminate soil and water, and plants may absorb them through their root systems. Consequently, when animals consume contaminated plants or drink contaminated water, the heavy metals accumulate in their tissues. Humans can then be exposed to these metals by consuming contaminated animal products.
3. Persistent organic pollutants (POPs): POPs are a group of chemical compounds that are resistant to environmental degradation. They include substances like polychlorinated biphenyls (PCBs), dioxins, and certain pesticides. POPs can be released into the environment through industrial processes, waste incineration, and the use of certain consumer products. They can accumulate in fatty tissues of animals and bioaccumulate up the food chain. As a result, predators or humans consuming contaminated animal products can be exposed to high levels of POPs.
4. Microplastics: Microplastics are small plastic particles less than 5mm in size. They can come from a variety of sources, such as plastic debris breakdown, microbeads in personal care products, and synthetic fibers from textiles. Microplastics can contaminate water bodies, and aquatic organisms

may ingest them. These organisms can then be consumed by larger fish or shellfish, which in turn can be consumed by humans. The long-term effects of microplastic ingestion on human health are still being studied, but their presence in the food chain raises concerns.

There are several pathways through which environmental pollutants enter the food chain:

1. Airborne Contaminants: Pollutants released into the atmosphere through industrial emissions, vehicular exhaust, and agricultural activities can be carried by air currents and deposited onto soil, water bodies, and crops. These contaminants can be in the form of gases, particulate matter, or volatile organic compounds. Through mechanisms like dry or wet deposition, they settle on vegetation, soil, and water surfaces, which are eventually consumed by animals or used for crop production.
2. Soil Contamination: Environmental pollutants can contaminate soil through various means, such as the application of chemical fertilizers, pesticides, and herbicides in agriculture, improper waste disposal, or accidental spills. Once in the soil, these contaminants can persist for long periods and may be taken up by plants. The pollutants can then accumulate in different parts of the plant, including edible portions, and enter the food chain when consumed by animals or humans.
3. Water Contamination: Water bodies can become polluted by industrial discharges, sewage, runoff from agricultural fields, or improper disposal of chemicals. These pollutants can include heavy metals, pesticides, pharmaceuticals, and other harmful substances. Aquatic organisms such as fish and shellfish can directly take in these contaminants from the water, and when consumed by humans, the pollutants enter the food chain.
4. Bioaccumulation and Biomagnification: Environmental pollutants have the ability to accumulate and magnify along the food chain. This process is known as bioaccumulation. Organisms at lower trophic levels absorb small amounts of pollutants from their environment, and as these organisms are consumed by predators, the pollutants are passed on and become more concentrated in the tissues of the higher trophic level species. This magnification of pollutant concentrations in higher trophic levels is called biomagnification. As a result, top predators in the food chain, including humans, may have the highest concentrations of pollutants in their bodies.

The entry of environmental pollutants into the food chain poses various risks:

1. Human Health: When contaminated food is consumed, pollutants can have adverse effects on human health. For example, heavy metals like lead and mercury can cause neurological damage,

while pesticide residues may have carcinogenic or endocrine-disrupting effects. Contaminants can accumulate in human tissues over time, leading to chronic health issues.

2. Ecological Impact: Environmental pollutants can harm wildlife and disrupt ecosystems. They can lead to the decline of certain species, interfere with reproductive processes, and affect the overall balance of ecosystems. The impacts can extend beyond individual organisms to population dynamics and biodiversity.
3. Food Safety and Security: Contaminated food poses a threat to food safety and security. If pollutants are present in significant quantities, it may lead to the withdrawal of food products from the market, economic losses for producers, and reduced consumer trust in the food system.

To mitigate the entry of environmental pollutants into the food chain, various measures can be taken:

1. Pollution Control: Stricter regulations and enforcement can help reduce pollution from industrial sources and agricultural practices. This can include the implementation of cleaner production technologies, waste management systems, and the promotion of sustainable farming practices.
2. Monitoring and Testing: Regular monitoring and testing of environmental samples, including soil, water, and food, can help identify and assess the presence of contaminants. This enables early detection and appropriate measures to mitigate risks.
3. Sustainable Agriculture: Promoting organic farming, integrated pest management, and the responsible use of fertilizers and pesticides can minimize the introduction of contaminants into the soil and water bodies.
4. Water Management: Proper wastewater treatment, reducing runoff from agricultural fields, and protecting water bodies from industrial pollution can help prevent water contamination and reduce the entry of pollutants into the food chain.
5. Public Awareness and Education: Increasing awareness among consumers about the risks associated with environmental pollutants in food can encourage informed choices and support demand for safer and sustainably produced food.
6. Regulation and policy: Governments enact regulations to control the use of pesticides, herbicides, and other chemicals to minimize their environmental impact and ensure safe levels in food. Regulatory agencies also establish maximum limits for pollutants in food products to protect public health.
7. Waste management and recycling: Proper waste management practices, including recycling and responsible disposal of hazardous materials, can prevent pollutants from entering the environment.

This includes implementing effective systems for the treatment and disposal of industrial waste and promoting recycling initiatives for plastic waste.

8. Monitoring and research: Continuous monitoring of food and environmental samples helps identify the presence of pollutants and assess their levels. Research plays a crucial role in understanding the impacts of different pollutants, their persistence in the environment, and their effects on human and ecological health. This knowledge informs policy decisions and the development of effective mitigation strategies.

In conclusion, environmental pollutants entering the food chain pose significant risks to human health and ecosystems. Understanding the sources, pathways, and impacts of these pollutants is crucial for implementing effective measures to minimize their entry and ensure the safety of the food we consume. Addressing the issue of environmental pollutants entering the food chain requires a holistic approach involving government policies, industry practices, scientific research, and individual actions. By reducing pollution at its source and implementing sustainable practices, we can safeguard both human health and the integrity of our ecosystems.

1.4 Lets sum up

This unit summarized xenobiotics and the source or mechanism of contamination.

1.5 Glossary

Xenobiotic- A substance that is not native to the body is called a xenobiotic (xenos "stranger"). Many biological consequences, such as pharmacological reactions, toxicity, immunological reactions, and cancers, can be caused by xenobiotics.

Deamination-the removal of an amino group from an amino acid or other compound.

Dehalogenation- the process of removing toxic substances or qualities.

Detoxification- the process of removing toxic substances or qualities.

Absorption: The process by which xenobiotics enter the body through various routes, such as ingestion, inhalation, or dermal exposure.

Bioavailability: The proportion of an administered xenobiotic that reaches the systemic circulation and is available to interact with its target site of action.

Biotransformation: The enzymatic conversion of xenobiotics within the body, often resulting in the formation of metabolites that may be more or less toxic than the parent compound.

Distribution: The movement of xenobiotics throughout the body, including their transport from the site of absorption to various tissues and organs.

Elimination: The removal of xenobiotics from the body, typically through processes such as metabolism, excretion via urine or feces, or exhalation.

Half-Life: The amount of time it takes for a xenobiotic's concentration in the body to drop by 50% is frequently used to gauge how quickly the substance is being eliminated.

Kinetics:the investigation of how quickly xenobiotics are absorbed, distributed, metabolized, and eliminated from the body.

Metabolism: The chemical modification of xenobiotics by enzymatic reactions, usually occurring in the liver, to facilitate their elimination from the body.

Pharmacodynamics: The study of the interactions between xenobiotics and their target sites of action within the body, including receptors, enzymes, or other biomolecules.

Pharmacokinetics: The study of the movement of xenobiotics within the body, including their absorption, distribution, metabolism, and elimination.

Route of Administration: The path through which xenobiotics are introduced into the body, such as oral (via the mouth), inhalation (via the respiratory system), or dermal (through the skin) routes.

Toxicokinetics: The study of the kinetics and dynamics of xenobiotics in relation to their toxic effects on the body.

Environmental Pollutants: Substances or agents that contaminate the environment, including air, water, soil, and ecosystems, and have the potential to cause harm to living organisms.

Food Chain: The sequence of transfers of energy and nutrients from one organism to another in an ecosystem, through various feeding relationships.

Bioaccumulation: The gradual buildup and concentration of pollutants in the tissues of living organisms over time, as they consume contaminated food or absorb pollutants from the environment.

Biomagnification: The process by which pollutants become increasingly concentrated in higher trophic levels of a food chain. Organisms at higher levels consume organisms lower in the food chain, accumulating higher levels of pollutants.

Persistent Organic Pollutants (POPs):organic substances that can withstand environmental deterioration and last for extended periods of time. Examples include specific pesticides like DDT and polychlorinated biphenyls (PCBs).

Heavy Metals: Metallic elements with high atomic weights that can be toxic to living organisms, even in small amounts. Examples include lead, mercury, cadmium, and arsenic. These metals can enter the food chain through industrial activities, mining, and agricultural practices.

Pesticides: Chemical substances used to kill or control pests, including insects, weeds, and fungi. Pesticides can enter the food chain when applied to crops or when animals consume contaminated plants.

Herbicides: Pesticides specifically designed to kill or control unwanted vegetation. Herbicides may enter the food chain when residues are present on crops or through runoff into water sources.

Insecticides: Pesticides used to eliminate or control insects. Insecticides can enter the food chain through direct application to crops, residues on plant surfaces, or ingestion by animals.

Fungicides: Pesticides employed to control or prevent the growth of fungi or molds. Fungicides can enter the food chain through residues on crops or by leaching into soil and water sources.

Antibiotics: Medications used to treat bacterial infections in humans and animals. When used in animal agriculture, antibiotics may enter the food chain through the consumption of treated animals or through residues in animal waste.

Polycyclic Aromatic Hydrocarbons (PAHs):a class of organic chemicals that are created when wood, fossil fuels, and other organic materials burn incompletely.

PAHs can enter the food chain through air or water pollution and are often found in grilled or smoked foods.

Dioxins: A family of highly toxic chemicals formed as byproducts of industrial processes, including waste incineration and paper bleaching. Dioxins can contaminate the food chain through bioaccumulation in animal tissues, especially in fatty foods like meat and dairy products.

Radionuclides: Radioactive isotopes released into the environment through nuclear accidents, nuclear weapons testing, or nuclear power generation. Radionuclides can enter the food chain through contaminated soil, water, and plants, posing a risk to human and animal health.

Microplastics: Tiny plastic particles, less than five millimeters in size, that come from microbeads found in personal care products or from the disintegration of bigger plastic objects. By being consumed by marine life, microplastics can make their way up the food chain and eventually make their way to humans through seafood.

PCBs (Polychlorinated Biphenyls): Synthetic organic compounds that were once employed in a variety of industrial settings, including plasticizers, hydraulic fluids, and electrical equipment.

PCBs can enter the food chain through bioaccumulation in fish and other aquatic organisms, representing a risk to both wildlife and humans.

1.6 Check Your Progress Exercises

I. **What is Xenobiotic?**

II. **Write down the effect of Xenobiotics on health.**

III. **Describe the** Detoxification process**?**

IV. **How do environmental pollutants enter in the food chain?**

V. **How can pollution affect food chains?**

VI. **What are environmental pollutants that can enter the food chain?**

VII. What are the potential health risks associated with environmental pollutants in the food chain?

VIII. What is the difference between dynamics and kinetics of xenobiotics?

IX. What are the factors that influence the bioavailability of xenobiotics?

X. What are the mechanisms of xenobiotic excretion from the body?

UNIT - II

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Overview

Block 1. Introduction and Significance of Toxicology in Food

Unit II: Introduction and significance of food toxicology

Food toxicology is a critical field of study that focuses on the detection, analysis, and evaluation of toxic substances present in food and their potential effects on human health. This abstract provides an introduction to food toxicology and highlights its significance in ensuring food safety and public health. The introduction outlines the fundamental principles of food toxicology, including the sources of food contaminants, the mechanisms of toxicity, and the routes of exposure. It emphasizes the interdisciplinary nature of the field, involving aspects of chemistry, biology, pharmacology, and risk assessment. The significance of food toxicology lies in its ability to identify and assess potential hazards in food, ranging from naturally occurring toxins to chemical contaminants and food additives. By understanding the toxicological properties of these substances, scientists and regulatory bodies can establish safe limits, develop effective control measures, and enforce stringent regulations to protect consumers from harmful effects. Ultimately, the importance of food toxicology cannot be overstated as it contributes to the development of evidence-based food safety guidelines, supports risk assessment and management, and plays a crucial role in safeguarding public health.

Unit 2- Introduction and significance of food toxicology

2.1 Introduction

When contaminated food is consumed, it can lead to food poisoning, also known as food-borne disease. Various bacteria, viruses, parasites, and their toxins are among the most frequent infectious organisms that cause food poisoning. Any stage of the production or processing of food might result in contamination by infectious organisms or their toxins. Additionally, improper handling or cooking of food might result in contamination at home. Just hours after consuming tainted food, food poisoning symptoms, such as nausea, vomiting, or diarrhea, might appear. The majority of food poisoning cases are minor and go away on their own. Hospitalization is necessary in certain severe situations, though. Food poisoning is a frequent ailment that can occasionally be fatal but is mostly mild. Common symptoms include cramping in the abdomen, diarrhea, nausea, and vomiting.

2.2.1 Types:

Food poisoning can have a wide variety of microbiological nonmicrobial causes.

There are two types of known causes of food poisoning: toxic agents and infectious agents. Parasites, bacteria, and viruses are examples of infectious agents.

Poisonous mushrooms, poorly prepared exotic meals (like barracuda-ciguatera toxin), and pesticides on fruits and vegetables are examples of toxic agents.

Microbial infection intoxication	**Bacterial** e.g., salmonella/staphylococcus, **viral** e.g., small-round-structured virus - **fungal** e.g., aspergillus (aflatoxin) - **protozoal** e.g., giardia
Microbial spoilage	Scombroid poisoning from bacterial spoilage of fish such as mackerel and tuna etc.
Poisonous animals	Shellfish poisoning caused by a 'red tide' of toxic dinoflagellates in plankton - ciguatera poisoning from fish living in tropical and subtropical waters following consumption of toxic dinoflagellates
Poisonous plants	Deadly nightshade, red kidney beans
Heavy metals	copper, zine, tin, lead
Pesticides and herbicides	Allergic or sensitivity reactions to certain foods

2.2.2 Causative factors

There are two groups into which the known causes of food poisoning fall: poisonous and infectious substances. Parasites, bacteria, and viruses are examples of infectious agents. Poisonous mushrooms, poorly prepared exotic meals (like barracuda-ciguatera toxin), and pesticides on fruits and vegetables are examples of toxic agents. Food contamination typically results from inadequate preparation or sanitation. Contamination is frequently caused by food handlers who have diseases or who do not wash their hands after using the restroom. Contamination is also encouraged by improperly packaged food that is kept at the incorrect temperature.

Either a single individual or a group of people who shared contaminated food can acquire food poisoning. After dining at restaurants, huge social gatherings, school cafeterias, or picnics, it happens more frequently.

The germs may get into the food you eat (called contamination) in different ways:

- Bacteria from the intestines of an animal being processed may come into contact with meat or poultry.
- Waste from humans or animals may be present in water used for growing or transportation.
- Food preparation or handling in households, restaurants, or supermarkets
- Any food made by someone who doesn't properly wash their hands
- Any dish cooked with partially unclean cutting boards, cooking utensils, and other equipment
- dairy items or mayonnaise-based foods (such potato salad or coleslaw) that have been left out of the fridge for an extended period of time.

- Foods that are frozen or refrigerated but are not adequately reheated or stored at the right temperature
- Raw fruit juices, vegetables, and dairy goods (look for the term "pasteurized," which indicates that the food has undergone a process to prevent contamination)
- Meats or eggs that are undercooked
- Many types of germs may cause food poisoning, including:
- Campylobacter enteritis
- Cholera
- E. coli enteritis
- Fish poisoning
- Staphylococcus aureus
- Salmonella
- Shigella

Infants and elderly people are at the greatest risk for food poisoning. You are also at higher risk if:

- ✓ You suffering from a severe illness, such diabetes or kidney problems.
- ✓ Your immune system is weaker.
- ✓ Women who are pregnant or nursing should use extra caution to prevent food poisoning.
- ✓ Food can spread more than 250 recognized diseases. Because persons with food poisoning have minimal symptoms and recover rapidly, many cases go unreported. Additionally, since testing for a cause does not alter the course of treatment or the result, clinicians do not do so in every suspected case.

The known causes of food poisoning can be divided into two categories:

Parasites, bacteria, and viruses are examples of infectious agents. Poisonous mushrooms, badly prepared exotic meals, and pesticides on fruits and vegetables are examples of toxic agents. Food contamination typically results from inadequate preparation or sanitation. Contamination is frequently caused by food handlers who have diseases or who do not wash their hands after using the restroom. Contamination is also encouraged by improperly packaged food that is kept at the incorrect temperature.

2.2.3 Signs and symptoms and preventive measures

The type of contaminant and the quantity consumed determine the symptoms of food poisoning. The symptoms may appear quickly—within 30 minutes—or they may appear gradually and get worse over the course of days or weeks.

Most of the common contaminants cause:

- nausea
- vomiting
- diarrhea

- abdominal cramping
- fever

Food poisoning often resolves in 24 to 48 hours and is not a dangerous sickness.

Viruses

Viruses are responsible for most food poisoning cases where a specific contaminant is identified. Among them, noroviruses are a major cause of mild illness, often referred to as "stomach flu," leading to nausea, vomiting, diarrhea, abdominal pain, headaches, and a low-grade fever. These symptoms typically subside within two to three days. Norovirus is the most prevalent viral cause of food poisoning in adults and spreads through contaminated water, shellfish, vegetables, and direct human contact. Outbreaks are especially frequent in crowded places such as nursing homes, schools, and cruise ships, hence the nickname "Cruise Ship Illness." The term "Norovirus" is the officially recognized name for this virus group, though it has also been known as Norwalk-like viruses, caliciviruses (due to their classification under the *Caliciviridae* family), and small round structured viruses.

Rotavirus causes moderate to severe infections, initially leading to vomiting, followed by watery diarrhea and fever. It is the primary cause of food poisoning in infants and young children, spreading through person-to-person contact via food or contaminated play areas.

Hepatitis A results in moderate illness, starting with fever, loss of appetite, abdominal pain, and fatigue, followed by jaundice (yellowing of the skin and eyes). Symptoms generally last less than two months, but in some cases, they can persist or relapse for up to six months. It is transmitted through fecal contamination of food by infected individuals.

Bacteria

Bacterial food poisoning occurs in two ways: Some bacteria infect the intestines, leading to inflammation and difficulty absorbing nutrients and water, resulting in diarrhea. Others produce toxins in food, which are harmful to the digestive system and can cause nausea, vomiting, kidney failure, or even death.

Salmonella refers to a group of bacteria responsible for food poisoning, commonly known as Salmonella infection. It leads to moderate illness characterized by nausea, vomiting, crampy diarrhea, and headaches. In some cases, it can trigger arthritis (joint pain) a few weeks later. Individuals with weakened immune systems, such as those with kidney disease, HIV/AIDS, or undergoing cancer chemotherapy, are at higher risk of developing life-threatening complications. It spreads through undercooked foods, including eggs, poultry, dairy products, and seafood.

Campylobacter causes mild illness, manifesting as fever, watery diarrhea, headaches, and muscle aches. It is the most frequently identified foodborne bacterial infection worldwide and is transmitted through raw poultry, unpasteurized milk, and water contaminated by animal feces.

Staphylococcus aureus triggers moderate to severe illness, with sudden nausea, severe vomiting, dizziness, and abdominal cramps. These bacteria produce toxins in foods such as cream-filled pastries, pies, and salads (including potato, macaroni, egg, and tuna salads). Improperly chilled picnic salads are a common source of contamination.

Bacillus cereus leads to mild illness, with rapid-onset vomiting, sometimes accompanied by diarrhea and abdominal cramps. It is commonly associated with starchy foods like rice (especially fried rice), pasta, and potatoes. There are concerns that this bacterium could be used as a biological weapon.

Escherichia coli (E. coli) can cause moderate to severe illness, beginning with large amounts of watery diarrhea, which may later turn bloody. While many strains exist, the most dangerous one can result in kidney failure and death in 3-5% of cases. It spreads through raw or undercooked hamburger, unpasteurized milk or juices, and contaminated well water. Outbreaks have also been linked to contaminated produce.

Shigella (Traveler'sdiarrhea) results in moderate to severe illness, characterized by fever, diarrhea containing blood or mucus, and a persistent urge to pass stool. It spreads through water contaminated with human waste.

Listeria monocytogenes causes *listeriosis*, which can lead to moderate to severe symptoms such as nausea and vomiting. In severe cases, it can progress to meningitis. It is transmitted through various uncooked foods, including meats, fruits, vegetables, soft cheeses, unpasteurized milk, and cold cuts. Pregnant women and newborns face a heightened risk of severe infection. A notable outbreak in 2011, caused by contaminated cantaloupe, resulted in 25 deaths and 123 infections across 26 states.

Clostridium botulinum (botulism) is a severe illness that affects the nervous system. It initially causes blurred vision, followed by speech difficulties, weakness, and, in severe cases, breathing problems and paralysis. Infants and young children are especially vulnerable. It spreads through home-canned foods, honey, sausages, and seafood. Because botulism can be dispersed through the air, it is considered a potential biological weapon.

Vibrio cholerae leads to mild to moderate illness, with symptoms such as crampy diarrhea, nausea, vomiting, headaches, fever, and chills. It is more common in warmer months and spreads through raw or undercooked seafood.

Vibrio parahaemolyticus causes moderate to severe abdominal cramps, nausea, vomiting, and fever. In individuals with weakened immune systems, it can result in a life-threatening illness. It is transmitted through consuming raw or undercooked seafood, particularly oysters.

Parasites

Although parasites rarely cause food poisoning, when they do, they are typically ingested through contaminated or untreated water, leading to prolonged but mild symptoms.

Giardia (Beaver fever) causes mild illness, primarily watery diarrhea that can persist for one to two weeks. It is contracted by drinking contaminated water, often from lakes or streams in cooler mountainous regions. Person-to-person transmission can also occur through food or objects contaminated with feces from an infected individual.

Pesticides

Exposure to pesticides can result in symptoms ranging from mild to severe, including weakness, blurred vision, headaches, abdominal cramps, diarrhea, excessive saliva production, and involuntary shaking of the limbs. These toxins are ingested through unwashed fruits or vegetables contaminated with pesticides.

Prevention

Ensuring safe food handling, cooking, and storage is crucial in preventing foodborne illnesses. Since bacteria are invisible and cannot be detected by smell or taste, food safety measures must be strictly followed.

To prevent food poisoning:

1. Control the initial number of bacteria present.
2. Prevent bacterial growth.
3. Eliminate bacteria through proper cooking.
4. Avoid recontamination of food.

2.3 Naturally Occurring Food Toxins, Their Adverse Effects, and Methods of Elimination

Natural toxins are hazardous compounds that are naturally synthesized by living organisms. While these toxins do not harm the organisms that produce them, they can be toxic to humans and other animals when consumed. These chemical substances exhibit a wide range of structures and vary in their biological roles and toxicity levels. Some toxins are produced by plants as a defense mechanism against predators, insects, or microorganisms, while others result from infestations of mold or reactions to environmental stressors such as extreme humidity or drought. Additionally, microscopic algae and plankton found in oceans and, at times, in lakes generate chemical compounds that are toxic to humans but not to the fish or shellfish that consume them. When humans ingest seafood containing these toxins, illness can develop rapidly.

Below are some of the most prevalent natural toxins that pose a potential health risk.

Aquatic Biotoxins

Toxins generated by algae in marine and freshwater environments are known as algal toxins. These toxins are produced during algal blooms of specific naturally occurring species. Shellfish, including mussels, scallops, and oysters, are more likely to accumulate these toxins than fish. Algal toxins can cause symptoms such as vomiting, diarrhea, tingling sensations, paralysis, and other health issues in humans, mammals, and fish. These toxins can remain in seafood and drinking water and are undetectable by taste or smell. Moreover, they cannot be neutralized through cooking or freezing.

Example – Ciguatera Poisoning

Ciguatera poisoning occurs when individuals consume fish that have accumulated toxins produced by the marine algae *Gambierdiscustoxicus*. This condition can range from moderate to severe, leading to symptoms such as numbness around the lips and mouth, which may extend to the arms and legs, as well as nausea, vomiting, muscle pain, weakness, dizziness, headaches, and an accelerated heart rate. A distinct symptom of ciguatera poisoning is sensory reversal, where hot sensations feel cold and vice versa. It is transmitted through the consumption of large predatory fish from tropical waters, including barracuda, snapper, grouper, and jacks. According to the CDC, there is no known cure for ciguatera poisoning. While symptoms may resolve within days or weeks, they can persist for years in some cases.

Cyanogenic Glycosides

- **Definition:** Naturally occurring compounds present in various plants that release cyanide when metabolized.
- **Harmful Effects:** Exposure to cyanide can cause symptoms such as dizziness, headaches, nausea, respiratory failure, and, in extreme cases, death.
- **Removal Methods:** Techniques such as soaking, cooking, fermenting, milling, grinding, and enzymatic treatments can significantly reduce cyanide levels in food.

Furocoumarins

These stress-induced toxins are found in plants such as parsnips, celery roots, citrus fruits (lemons, limes, grapefruits, bergamot), and some medicinal herbs. Furocoumarins are released when plants experience physical damage or environmental stress. In susceptible individuals, these compounds can cause gastrointestinal distress. Additionally, they are phototoxic, meaning they can trigger severe skin reactions when exposed to sunlight (UVA radiation). While skin reactions are more common, ingestion of large amounts of foods containing high furocoumarin levels has also led to similar effects.

Lectins

- **Definition:** Naturally occurring proteins found in legumes, grains, and certain vegetables.
- **Harmful Effects:** Some lectins can disrupt nutrient absorption, cause digestive issues, and damage the intestinal lining.
- **Removal Methods:** Soaking, fermenting, and cooking can help lower lectin content and reduce their adverse effects.

Mycotoxins

Mycotoxins are toxic compounds naturally produced by certain molds. These molds can grow on various food products, including cereals, dried fruits, nuts, and spices, often thriving under warm and humid conditions. Mycotoxins remain stable during food processing, making them particularly hazardous. Acute exposure to these toxins can cause severe illness or even death. Long-term consumption of food contaminated with mycotoxins has been associated with cancer and immune system suppression.

Solanine

- **Definition:** A toxic alkaloid naturally occurring in nightshade vegetables such as potatoes, tomatoes, and eggplants.
- **Harmful Effects:** High solanine intake can lead to nausea, vomiting, diarrhea, neurological symptoms, and, in extreme cases, coma.
- **Removal Methods:** Peeling, cooking, and subjecting food to high-temperature processing methods such as baking or frying can significantly lower solanine levels.

Pyrrolizidine Alkaloids (PAs)

Produced by over 600 plant species, pyrrolizidine alkaloids are mainly found in the Boraginaceae, Asteraceae, and Fabaceae families. These toxins are often introduced into the food chain when PA-producing weeds contaminate agricultural fields. PAs can be acutely toxic and have DNA-damaging properties, potentially leading to cancer. These toxins persist through food processing and have been detected in herbal teas, honey, spices, and cereals. Although human exposure is considered low, international food safety agencies continue to assess the health risks associated with PAs. The FAO/WHO Codex Committee is actively developing strategies to prevent PA contamination in food products.

Aflatoxins

- **Definition:** A group of toxic compounds produced by molds such as *Aspergillus flavus* and *Aspergillus parasiticus*.
- **Harmful Effects:** Aflatoxins are highly carcinogenic and can cause liver damage, immune suppression, developmental disorders, and stunted growth.
- **Removal Methods:** Proper storage practices that minimize moisture and maximize ventilation can help reduce aflatoxin contamination. Post-harvest techniques such as washing, sorting, and activated charcoal treatments can further mitigate aflatoxin levels.

Mushroom Toxins

The severity of mushroom poisoning depends on the species consumed. Some mushrooms cause mild nausea, vomiting, and diarrhea, while others produce neurotoxins that can induce hallucinations, sweating, tremors, and coma.

Scombroid Poisoning

Scombroid poisoning results in mild to moderate symptoms, including facial flushing, burning sensations around the mouth and lips, a peppery taste, a red rash on the upper body, dizziness, headaches, and itchy skin. Severe cases may involve blurred vision, respiratory distress, and swelling of the tongue and mouth. Symptoms typically last between four to six hours but can persist for one or two days. This condition is linked to the consumption of seafood, particularly mahi-mahi, tuna, and Swiss cheese.

Antivitamins

Certain food compounds interfere with vitamin absorption, leading to deficiencies.

- **Example:** Avidin, found in raw egg whites, binds to biotin, preventing its absorption. However, avidin is inactivated by cooking, making raw egg consumption a rare cause of biotin deficiency.

Mineral-Binding Agents

Goitrogens

These compounds, found in cruciferous vegetables like cabbage, Brussels sprouts, and broccoli, interfere with iodine absorption by the thyroid gland. While normal consumption is not harmful, excessive intake in areas with low dietary iodine may contribute to goiter development.

Oxalates

- **Definition:** Naturally occurring compounds found in foods such as spinach, rhubarb, beets, nuts, and seeds.
- **Harmful Effects:** Can contribute to kidney stone formation and hinder calcium absorption.
- **Removal Methods:** Boiling or blanching can help remove oxalates, while consuming calcium-rich foods alongside oxalate-containing foods can reduce their impact.

Methods of removal / reduction of natural toxins

Various processing techniques can minimize natural toxin levels in food, including peeling, cutting, soaking, cooking, boiling, blanching, drying, and fermentation. In addition to pre-harvest biocontrol strategies, emerging post-harvest methods such as microwave heating, gamma irradiation, pulsed light, UV light, cold plasma, organic and inorganic acids, and mycotoxin-binding agents have shown promise in toxin reduction.

1. **Physical Methods**

   A. **Sorting & Cleaning:**

   a. Manual Sorting: Removing visibly contaminated or damaged food items (e.g., moldy grains or spoiled nuts).
   b. Washing: Rinsing fruits, vegetables, and grains with water to remove surface contaminants like aflatoxins or pesticide residues.
   c. Peeling: Removing the outer layers of fruits and vegetables, where toxins like glycoalkaloids in potatoes may concentrate.

   B. Heat Treatment:

a. Cooking: Boiling, steaming, or frying can degrade heat-labile toxins like lectins in legumes or cyanogenic glycosides in cassava.
b. Roasting: Effective for reducing aflatoxins in nuts and seeds.
c. Pasteurization: Used for liquid foods to destroy heat-sensitive toxins and microorganisms.

C. **Irradiation**

Exposure to gamma rays or ultraviolet (UV) light can reduce microbial contamination and degrade certain toxins, such as mycotoxins in grains.

D. **Filtration**

Used in liquid foods (e.g., fruit juices) to remove particulate matter and microbial contaminants.

2. Chemical Methods

Chemical methods involve the use of agents to neutralize or degrade toxins.

A. . Alkaline Treatment

Soaking or treating foods with alkaline solutions (e.g., lime water) can degrade toxins like cyanogenic glycosides in cassava or aflatoxins in grains.

B. Detoxification with Acids

Acidic solutions (e.g., citric acid or vinegar) can reduce certain toxins, such as patulin in apple juice.

C. Oxidation

Using oxidizing agents like hydrogen peroxide or ozone to break down toxins like mycotoxins in grains.

D. Chelation

Adding chelating agents (e.g., EDTA) to bind and remove heavy metals or other toxic elements from food.

3. Biological Methods

   Biological methods use microorganisms or enzymes to degrade toxins.

A. Fermentation

Fermenting foods with beneficial bacteria or yeast can reduce toxins like aflatoxins, cyanogenic glycosides, or phytates. For ex. fermentation of cassava to reduce cyanide or fermentation of soybeans to reduce anti-nutritional factors.

B. Enzymatic Detoxification

Using specific enzymes (e.g., lactase, phytase) to break down toxins or anti-nutritional factors in food.

C. Biocontrol Agents

Introducing non-toxigenic strains of microorganisms to compete with toxin-producing strains (e.g., using non-aflatoxigenic Aspergillus strains to prevent aflatoxin contamination).

4. Genetic and Agricultural Methods: These methods focus on preventing toxin formation at the source.

   A. Crop Breeding

   Developing toxin-resistant or low-toxin crop varieties through traditional breeding or genetic engineering. Like breeding low-cyanide cassava or low-glycoalkaloid potatoes.

   B. Good Agricultural Practices (GAP)

   Implementing proper farming techniques to minimize fungal or microbial contamination (e.g., crop rotation, proper irrigation, and pest control).

   C. Post-Harvest Management

   Storing food under controlled conditions (e.g., low humidity, cool temperatures) to prevent fungal growth and toxin production.

5. Modern Technologies

A. Adsorption: Using adsorbent materials (e.g., activated charcoal, clay, or specific resins) to bind and remove toxins like mycotoxins from liquids or oils.
B. Membrane Filtration: Using ultrafiltration or nanofiltration to separate toxins from liquid foods.
C. High-Pressure Processing (HPP): Applying high pressure to inactivate microorganisms and degrade certain toxins without heat.
D. Pulsed Light and Cold Plasma Treatment: Using ionized gas to degrade toxins and microbial contaminants on food surfaces.
E. Gamma Irradiation: Reduces microbial toxins like aflatoxins and patulin.
F. Ultraviolet (UV) Treatment: Used for detoxifying fungal toxins in fruit juices and grains.
G. Extrusion Cooking: High-temperature and pressure processing to reduce mycotoxins in cereals.

6. Combination Methods

   Combining multiple methods often yields better results in toxin removal. For example, washing followed by heat treatment or fermentation combined with adsorption.

Lets sum up

Food toxicology is the study of harmful substances in food, their effects on health, and methods to mitigate their risks. It plays a critical role in ensuring food safety by identifying and managing natural toxins, contaminants, and chemical residues that can pose health hazards. Understanding food toxicology helps prevent foodborne illnesses, protect public health, and ensure the safety of the food supply chain. In conclusion, food toxicology is vital for safeguarding consumers, guiding regulatory standards, and promoting the consumption of safe and wholesome food. The removal of natural toxins from food is essential to ensure food safety and protect public health. Various methods, including physical processes like sorting, washing, and heat treatment, chemical treatments such as alkali or acid solutions, biological approaches like fermentation, and genetic modifications, can effectively reduce or eliminate toxins. Proper storage and environmental control also play a critical role in preventing toxin formation. The choice of method depends on the type of toxin and the food involved, and often, a combination of techniques yields the best results. Adhering to food safety guidelines and regulations is crucial to minimize risks and ensure the consumption of safe, toxin-free food.

Glossary

Food poisoning, or foodborne illness, occurs when you eat contaminated food.

4C's: refer to the food safety: Clean, Contain, Cook and Chill.

Food toxins: Food toxins are natural substances covering a large variety of molecules, generated by fungi, algae, plants, or bacteria metabolism with harmful effects on humans even at very low doses.

Detoxification:the process of removing toxic substances

Preventive actions:Action to eliminate the cause of a potential nonconformity or other potential undesirable situation.

Corrective actions: It is a particular action aimed at removing the cause of product failures and nonconformities in an effort to prevent their future recurrence.Pathogens: Microorganisms, including bacteria, viruses, and parasites, that can cause food poisoning when present in food. Common pathogens include Salmonella, E. coli, Campylobacter, Norovirus, and Listeria.

Contamination: The presence of harmful substances or pathogens in food that can lead to food poisoning. Contamination can occur during various stages, such as production, processing, handling, storage, or preparation.

Cross-contamination: The transfer of harmful substances or pathogens from one food item to another, typically through contact with contaminated surfaces, utensils, or hands. It can occur between raw and cooked foods or between different raw foods.

Toxin: A poisonous substance produced by certain bacteria, such as Clostridium botulinum, which can cause severe food poisoning. Toxins are often heat-stable and can remain in food even after the bacteria have been killed.

Incubation period: The time between consuming contaminated food and the onset of symptoms. It varies depending on the type of pathogen involved, ranging from a few hours to several days.

Gastroenteritis: Inflammation of the gastrointestinal tract, commonly caused by food poisoning. It results in symptoms like vomiting, diarrhea, abdominal cramps, and sometimes fever.

Foodborne illness: A broader term encompassing any illness or disease caused by consuming contaminated food or beverages, including food poisoning. It can also include infections caused by parasites and non-infectious illnesses due to toxins or chemicals in food.

HACCP: Hazard Analysis and Critical Control Points. It is a systematic preventive approach used in the food industry to identify and control potential hazards at specific stages of food production and processing, aiming to ensure food safety.

Food safety: Measures and practices taken to prevent food contamination and minimize the risk of foodborne illnesses. This includes proper storage, handling, cooking, and hygiene practices to ensure the safety of the food supply chain.

Hygiene: Practices and conditions that promote cleanliness and prevent the spread of harmful microorganisms. Good personal hygiene, such as handwashing, and maintaining clean food preparation areas are essential for preventing food poisoning.

Refrigeration: The process of cooling and storing food at low temperatures to inhibit the growth of bacteria and other pathogens. Refrigeration slows down the spoilage process, extending the shelf life of perishable foods.

Pasteurization: A heat treatment process used to kill pathogens and extend the shelf life of certain foods, such as milk and juices. It involves heating the food to a specific temperature for a set period to destroy harmful microorganisms.

Outbreak: The occurrence of a higher number of cases of food poisoning or a similar illness within a specific population and time period, indicating a common source of contamination.

Food recall: The process of removing or correcting food products from the market due to identified safety concerns. Recalls occur when a food product is found to be contaminated or potentially harmful to consumers.

Foodborne intoxication: A type of food poisoning caused by consuming food containing pre-formed toxins produced by bacteria, such as Staphylococcus aureus or Bacillus cereus. Symptoms can occur rapidly after ingestion.

Safe minimum internal temperature: The temperature at which different foods should be cooked to ensure that harmful bacteria are killed. It varies depending on the type of food and can be measured using a food thermometer.

Dehydration: The excessive loss of body fluids, particularly water, often caused by vomiting and diarrhea during food poisoning. Dehydration can be severe, especially in vulnerable populations such as children and the elderly.

Antimicrobial resistance: The ability of bacteria to survive and grow despite exposure to antibiotics or other antimicrobial drugs. It is a growing concern in food safety as it reduces the effectiveness of treatments for foodborne illnesses.

Food handler: Any person involved in the production, preparation, packaging, or serving of food. Proper training and adherence to hygiene practices are crucial for food handlers to prevent food poisoning.

Check Your Progress Exercise

I. What are natural toxins?

II. How to remove toxins?

III. What are the signs, symptoms, and preventive measures of food poisoning?

IV. **Explain the types of food poisoning.**

V. **What are naturally occurring food toxins and how do they differ from microbial contaminants?**

VI. **Could you provide some examples of naturally occurring food toxins and the foods they are commonly found in?**

VII. **What are the harmful effects of naturally occurring food toxins on human health?**

VIII. How does food contamination occur and what are the main sources of foodborne pathogens?

IX. Can you explain the importance of proper storage and handling practices in preventing food poisoning from naturally occurring toxins?

X. Are there any specific symptoms or signs that can help distinguish food poisoning caused by naturally occurring toxins from other types of foodborne illnesses?

UNIT - III

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Overview

BLOCK-2 Food Safety Laws and Standards

Unit III: Microbial and chemical toxins (Microbial toxins and food intoxication)

This unit delves into the fascinating field of microbial toxins and their role in food intoxications. Microorganisms, such as bacteria, fungi, and viruses, have developed various mechanisms to produce toxins that can cause detrimental effects on human health when ingested through contaminated food. This overview focuses on the diverse types of microbial toxins encountered in foodborne illnesses, shedding light on their characteristics, sources, and modes of action.

Unit III -Microbial and chemical toxins (Microbial toxins and food intoxication)

3.1 Introduction

Food contamination refers to the unintended presence of harmful chemicals or microorganisms in food, which can pose health risks to consumers. A food contaminant is any substance that unintentionally enters food during its production, processing, packaging, transportation, or storage, as well as through environmental exposure. Preventing contamination is crucial to ensuring food safety and avoiding foodborne illnesses and the introduction of foreign substances.

3.2 Sources of Contamination

Food contamination can occur through three primary means: (i) Microbial Contamination, (ii) Physical Contamination, and (iii) Chemical Contamination.

I. Microbial Contamination

Consumption of food contaminated with harmful bacteria (pathogenic bacteria) or the toxins they produce can lead to foodborne illnesses. Bacteria are the leading cause of food poisoning, with symptoms including vomiting, diarrhea, fever, and abdominal pain. The onset of symptoms varies depending on the bacterial type and its incubation period. Bacteria must typically multiply to a significant level in food to cause infection, while some toxins act immediately upon ingestion. Notably, food contaminated with pathogenic bacteria often appears, smells, and tastes normal, making prevention essential. Some fungal toxins of concern include:

a. Mycotoxins:

These toxic substances are produced by molds and fungi, with some exhibiting mutagenic and carcinogenic properties. Aflatoxins are among the most commonly found mycotoxins in agricultural products.

b. Aflatoxins:

Produced by *Aspergillus flavus* and *Aspergillus parasiticus*, these toxins include variants such as B1, B2, M1, M2, G1, and G2, which frequently contaminate crops like maize, rice, sorghum, groundnuts, wheat, barley, and soybeans. Aflatoxins are resistant to high temperatures, meaning their toxicity remains even after cooking. Other important mycotoxins include citrinin, ochratoxin, and patulin, mainly produced by *Penicillium* species. The permissible limit for mycotoxins in stored grains is 30 micrograms per kilogram, as per CWC/SWC/FCI regulations.

c. Ergot: Produced by *Claviceps purpurea*, this mycotoxin contaminates rye and pearl millet, causing ergot disease. Proper drying of crops and maintaining moisture levels within safe limits can prevent this contamination.

II. Physical Contamination

Physical contamination occurs when foreign materials enter food during any stage of the supply chain. Agricultural produce can become contaminated with various external materials categorized as organic or inorganic contaminants. Organic contaminants include plant debris, weed seeds, toxic seeds (such as *Datura* and *Akra*), other grains, dead insects, excreta, and rodent hairs, while inorganic contaminants include soil, pebbles, stones, and dust. The quality and shelf life of food products depend on the extent of these contaminants. Preventative measures such as cleaning, grading, and packaging in infestation-free materials help ensure food safety. Examples of physical contaminants include:

a. Machinery Fragments: Small pieces of equipment may accidentally enter food during manufacturing. Metal detectors on production lines help eliminate such risks.

b. Natural Impurities: Stones, shells, bones, and twigs can find their way into food products.

c. Foreign Objects from Handling: Contaminants like jewelry and cigarette ashes can enter food due to poor food handling practices. Strict hygiene measures must be followed to prevent this.

III. Chemical Contamination

Chemical contamination occurs due to environmental pollutants, agrochemicals, food processing reactions, or exposure to harmful substances during storage and transportation. Chemicals such as pesticides, cleaning agents, and industrial pollutants can contaminate food and pose health risks. Unlike microbial contaminants, most chemical contaminants remain unaffected by heat treatment. They can be categorized based on their sources:

1. **Agrochemical Contaminants**: These include pesticides (e.g., insecticides, herbicides, rodenticides), plant growth regulators, and veterinary drugs such as nitrofuran, fluoroquinolones, and bovine somatotropin (rBST).
2. **Environmental Contaminants**: These are chemicals from the air, water, and soil that can enter the food supply. Some examples include:
   - **Air**: Radionuclides (137Caesium, 90Strontium), polycyclic aromatic hydrocarbons (PAH).
   - **Water**: Heavy metals like arsenic and mercury.
   - **Soil**: Contaminants such as cadmium, nitrates, and perchlorates.
   - **Packaging Materials**: Substances like antimony, tin, lead, bisphenol A, and benzophenone.
   - **Processing Equipment**: Traces of copper, lubricants, or cleaning agents.
   - **Naturally Occurring Toxins**: Examples include mycotoxins, phytohaemagglutinin, pyrrolizidine alkaloids, shellfish toxins, and tetrodotoxin.
3. **Processing Contaminants**: These contaminants form during food processing through chemical reactions among food components. Examples include nitrosamines, polycyclic aromatic hydrocarbons (PAH), heterocyclic amines, acrylamide, trans fats, benzene, and ethyl carbamate.

3.3 Effects on Health

Chemical contaminants can enter the environment through industrial, commercial, and residential activities, affecting air, water, and soil. Human exposure to these contaminants occurs through inhalation, ingestion, or skin contact. Health issues arising from exposure depend on factors such as duration, concentration, genetics, pre-existing health conditions, and age. Common health effects include respiratory problems (e.g., asthma), cardiovascular diseases, and certain cancers. While exposure does not always lead to illness, long-term exposure to even low levels of contaminants can have serious health implications. Foodborne illnesses due to microbial contamination remain widespread, making it essential to implement food safety measures to mitigate risks. Some of the food borne diseases are mentioned below

S.No.	Contaminants	Health effects
1.	*Staphylococcus aureus*	Gastroenteritis
2.	*Clostridium botulinum*	Botulism
3.	*Bacillus cereus*	Diarrhea
4.	*Salmonella typhi*	Enteric fever typhoid, food borne salmonellosis
5.	*Escherichia coli*	Gastroenteritis, diarrhea
6.	toxic metals, polychlorinated biphenyls and dioxins, or pesticides, veterinary medicinal products	gastrointestinal illness, liver cancer, neurobehavioural effects or aplastic anaemia
7.	Polyaromatic hydrocarbons	Mutagenicity and carcinogenicity, DNA damage, oxidative stress, impaired male fertility, respiratory diseases, cognitive dysfunction among children and cancer (breast cancer)
8.	Organochlorine pesticides	Neurological symptoms, endocrine disruption, infertility and fetal malformation, diabetes, cancer (breast cancer, testicular, prostate and kidney cancer), reproductive problems, cardiovascular problems, high blood pressure, glucose intolerance and obesity
9.	Dioxins/furans	Language delay, disturbances in mental and motor development, cancer, diabetes, endocrine disruption, high blood pressure, glucose intolerance and cardiovascular problems
10.	Polychlorinated biphenyls	Endocrine disruption, neurological disorders, liver injury, diabetes, cancer (breast, prostate, testicular, kidney,

		ovarian and uterine cancers), cardiovascular problems and obesity
11.	Polybrominated diphenyl ethers	Reproductive problems, cancer(testicular), diabetes, obesity and cardiovascular problems
12.	Perfluorooctanesulfonate (PFOS) and Perfluorooctanoic acid	Breast cancer
13.	Hexabromocyclododecanes	Endocrine disruption, reproductive problems and behavioral effects
14.	Polychlorinated naphthalenes	Cancers

3.4 Preventive measures and methods of inactivation and destruction

PREVENTIVE MEASURES

Causes and Prevention of Foodborne Illness

Foodborne illnesses can affect anyone consuming contaminated food; however, some individuals are more vulnerable to severe illness. These at-risk groups include infants, young children, elderly individuals, pregnant women, those taking certain medications, and individuals with weakened immune systems, such as cancer patients and people with diabetes. To minimize the risk of foodborne illness, it is crucial to understand how food contamination occurs and implement proper safety measures.

Primary Causes of Foodborne Illness

Foodborne illnesses arise from three main categories of hazards:

- **Biological Hazards**: These include bacteria, viruses, and parasites, with bacteria and viruses being the most frequent culprits. Biological hazards present the greatest risk to food safety, as they may be inherent in the food or introduced due to improper handling, such as inadequate temperature control.
- **Chemical Hazards**: These consist of natural toxins and chemical contaminants. Some toxins are naturally present in food (e.g., specific mushrooms, paralytic shellfish poisoning in mollusks), while others develop when food is stored improperly (e.g., histamine formation in certain

seafood). Some food additives, such as sulfites, can be harmful to sensitive individuals. Chemical contamination may also result from incorrect use of cleaning agents and sanitizers.

- **Food Allergens**: Classified as chemical hazards, food allergens can cause severe reactions in sensitive individuals. Different foods pose different risks, and regulatory agencies have identified eight primary allergens responsible for 90% of allergic reactions: milk, eggs, fish, crustacean shellfish (lobster, crab, shrimp), wheat, soy, peanuts, and tree nuts.
- **Physical Hazards**: These include foreign materials such as metal fragments from cans, wire bristles from grills, plastic pieces, or broken glass that may accidentally enter food.

Key Steps for Ensuring Food Safety

Following these four essential food safety practices helps prevent foodborne illnesses:

1. Clean

- Wash hands, food contact surfaces, and utensils frequently, especially between tasks or when contaminated.
- Effective cleaning involves removing dirt and debris, scrubbing with hot, soapy water, rinsing with potable water, and ensuring proper drying.
- Sanitization involves using high temperatures (e.g., dishwashers) or chemicals (e.g., chlorine bleach) to reduce microbial presence to safe levels.
- Wash hands with warm, soapy water for at least 20 seconds and dry with a disposable paper towel or clean cloth.
- Hand sanitizers are not a substitute for handwashing, as they are ineffective against certain microorganisms and do not remove dirt or grease.
- Wash cutting boards, dishes, and utensils after each use and before handling different food items.
- Disinfect countertops and surfaces with hot, soapy water, rinse with clean water, and air-dry or wipe with a clean towel.
- If additional sanitization is desired, a diluted chlorine bleach solution can be used (1 teaspoon of 8.25% bleach per gallon of water, or 1/8 teaspoon per pint of water). Apply, let sit for 1–2 minutes, and allow to air dry.
- Regularly wash dishcloths in the washing machine and allow sponges to dry properly after use.

- Sanitize sponges frequently by soaking them in a bleach solution, microwaving a damp sponge for one minute, or running them through the dishwasher.
- Replace dish sponges regularly.

2. Separate

Cross-contamination occurs when harmful bacteria from raw foods come into contact with ready-to-eat foods, kitchen surfaces, or equipment. Preventing cross-contamination is essential:

- While Shopping:
  - Separate raw meat, poultry, and seafood from other groceries.
  - Use plastic bags to prevent raw juices from contaminating other food.
  - Designate specific reusable bags for raw meats and wash them regularly.
- During Storage:
  - Store raw meats, fish, and poultry below ready-to-eat foods in the refrigerator.
  - Thaw frozen raw meats in a leak-proof bag or on a plate to prevent drippings from contaminating other items.
- During Preparation:
  - Wash hands thoroughly before and after handling different food items.
  - Use separate cutting boards for raw meat and produce.
  - Wash and sanitize knives, cutting boards, and preparation surfaces after handling raw foods.
  - Use a clean plate for serving cooked food—never reuse the plate that held raw food unless washed properly.
  - Discard marinades used for raw meat, fish, or poultry unless they are boiled before reuse.

3. Cook

- Cook foods to their safe internal temperatures to eliminate harmful bacteria.
- Use a food thermometer to check the thickest part of the food, ensuring it is not touching bone, fat, or gristle.

- For whole poultry, insert the thermometer into the innermost part of the thigh and wing, as well as the thickest section of the breast.
- For mixed dishes, such as casseroles or egg-based dishes, test the internal temperature in multiple areas.
- Clean food thermometers with hot, soapy water before and after each use.

4. Chill

- Cold temperatures slow bacterial growth, so maintain refrigerators at 41°F or below and freezers at 0°F or below.
- Avoid overfilling the refrigerator to ensure adequate air circulation.
- Store perishable foods, including raw meats, poultry, and dairy products, in the refrigerator or freezer as soon as possible after purchase.
- Use a cooler with ice packs when transporting perishable food.
- Do not leave perishable foods at room temperature for more than two hours (or one hour if above 90°F).
- Safe Thawing Methods:
  - Refrigerator Thawing: Keeps food safe for a few days before cooking and allows refreezing if needed.
  - Cold Water Thawing: Submerge food in a leak-proof bag in cold water, changing the water every 30 minutes. Cook immediately.
  - Microwave Thawing: Cook food immediately after thawing, as some areas may begin to cook during the process.
- Cool large portions of leftovers quickly by dividing them into shallow containers before refrigeration.

Control of Microorganisms

Controlling the growth of microorganisms and preventing the spread of infectious diseases involves halting their growth temporarily, reducing their numbers to a safe level, or completely eliminating them. The effectiveness of these control methods depends on several factors, including the quantity and type of microorganisms, their physiological condition (such as growth stage or endospore formation), and the environment in which they exist (e.g., glassware, instruments, tissues, or food).

Methods for Destroying Microorganisms

1. **Sterilization** – The complete eradication of all microorganisms, including endospores, from an object or material.
2. **Disinfection** – The elimination of pathogenic microorganisms, excluding endospores, from surfaces or materials. This process lowers the number of pathogens or inhibits their growth to a level that does not cause disease.
3. **Antisepsis** – The application of chemical disinfectants to the skin, mucous membranes, or other living tissues to prevent infection.
4. **Germicide** – A chemical substance specifically designed to destroy microorganisms. Different types of germicides target various microorganisms.
5. **Asepsis** – The absence of pathogenic microorganisms in a particular area or object. Aseptic techniques help prevent the introduction of harmful pathogens into the body.
6. **Sanitization** – The process of reducing or eliminating pathogens on non-living surfaces through chemical or mechanical cleaning methods.
7. **Bacteriostasis** – A method that inhibits bacterial growth and reproduction without necessarily killing the bacteria.

Physical Agents for Microbial Control

1. **Heat**

   Heat is the most widely used, cost-effective, straightforward, reliable, and efficient method for destroying microorganisms. It works by denaturing the proteins and enzymes of microbes. Most pathogens are eliminated at temperatures between 50°C and 70°C within 10 minutes, but endospores may require 1 to 2 hours at 100°C to be completely destroyed. Heat sterilization is categorized into moist heat and dry heat methods.

A. Moist Heat

1. **Boiling –** Most bacteria, fungi, and viruses are eliminated by boiling at 100°C for 10 to 30 minutes. However, some viruses and endospores may require prolonged boiling for up to 20 hours. This process sterilizes by denaturing microbial proteins and enzymes.

2. **Steam Under Pressure** – Heating water under pressure raises the temperature above 100°C, effectively denaturing proteins and amino acids. The most common device for this method is an autoclave, used for sterilizing surgical instruments, bandages, media, and contaminated materials. A pressure of 15 pounds per square inch at 121°C for 15 to 20 minutes ensures the destruction of both microorganisms and endospores.

3. **Pasteurization** – Primarily used in the food and dairy industries, pasteurization involves heating substances to temperatures high enough to eliminate pathogens or inhibit their growth without compromising the product's quality.

B. Dry Heat

Dry heat is slower at penetrating materials compared to moist heat.

1. **Incineration** – The complete burning of disposable materials to destroy microorganisms.

2. **Direct Flaming** – The sterilization of inoculating loops, needles, and test tube rims using a Bunsen burner. Heating metal to a red-hot state ensures 100% sterilization.

3. **Hot-Air Oven** – Used for sterilizing glassware, petri dishes, test tubes, syringes, and needles. This method requires higher temperatures and longer exposure times. Most endospores are destroyed at 160–165°C after 2 hours.

4. **Cold**
The impact of low temperatures on microorganisms depends on the type of microbe and the intensity of the cold. Refrigeration temperatures (0–8°C) have a bacteriostatic effect, slowing down the metabolic activity of most organisms, preventing reproduction and toxin production. Freezing at -20°C kills most bacteria, but some may survive in a dormant state.

5. **DryingorDesiccation**
Microorganisms need water to grow and reproduce. The removal of water through evaporation or freeze-drying (converting solid to gas) halts enzyme activity, preventing microbial growth and reproduction. However, some microbes can remain viable for years and resume growth once water is reintroduced.

6. **Ultraviolet (UV) and Ionizing Radiation** (X-rays and Gamma Rays)
Both forms of radiation damage microbial DNA and denature proteins. UV radiation is effective on surfaces but cannot penetrate materials such as glass, dirt, clothing, paper, or pus. It is

commonly used in germicidal lamps in operating rooms, nurseries, and disease wards to lower airborne bacterial levels, though it does not provide complete sterilization.

7. **Filtration**

   Filtration involves passing air or liquids through filters with tiny pores that trap microorganisms. Membrane filters made of cellulose acetate are commonly used, while materials like gauze, cotton, and paper serve as air filters. Certain vaccines, such as polio vaccines, require live viruses and are passed through specialized filters that remove bacteria while allowing viruses to pass through. Air filtration systems in operating rooms help reduce airborne microbial contamination.

Chemical Agents for Microbial Control

Chemical agents are employed to inhibit the growth of microorganisms on both non-living surfaces and living tissues. While most chemical agents function to reduce microbial populations (disinfectants), they do not necessarily achieve complete sterility. The choice of an appropriate disinfectant depends on factors such as its mechanism of action, required concentration, type and number of microorganisms, the material being disinfected, temperature, and pH.

Disinfectants are categorized based on their chemical composition and effectiveness.

3.5 Chemical Toxins

Chemical toxins encompass both inorganic substances like lead, mercury, hydrofluoric acid, and chlorine gas, as well as organic compounds such as methyl alcohol, certain medications, and naturally occurring poisons. While mildly radioactive substances like uranium fall under chemical toxins, highly radioactive materials such as radium do not; their harmful effects result from ionizing radiation rather than chemical interactions.

Toxic chemicals can enter food through various means:

- As preservatives in processed foods
- From raw ingredients, such as fish, which may contain toxic compounds like polychlorinated biphenyls (PCBs), as well as residues of pesticides and insecticides
- Through packaging materials that may leach harmful substances into food

3.5.1 Pesticides

Pesticides are chemical substances, either organic or inorganic, used in agriculture, industry, and households to eliminate, control, or suppress unwanted plants (weeds), pests (insects, worms, mollusks, and rodents), and microorganisms.

3.5.2 Insecticides

Insecticides are chemicals specifically formulated to exterminate insects or prevent them from engaging in harmful behaviors. They are primarily used to protect crops from infestations or to eliminate insects that transmit diseases. This category includes ovicides (targeting insect eggs) and larvicides (targeting insect larvae).

3.5.3 Metallic Toxins

Metallic toxins, commonly referred to as heavy metals, are harmful metals and their compounds that pose health risks to humans. The most concerning heavy metals in terms of human poisoning include lead, mercury, arsenic, cadmium, nickel, and zinc. Due to their widespread environmental contamination, heavy metals can accumulate in a variety of food sources, including:

- Plant-based foods such as cereals, rice, wheat, root vegetables, and mushrooms
- Animal-based foods such as fish, crustaceans, and mollusks

3.5.4 Residual Effects of Pesticides, Insecticides, and Metal Toxins

- **Movement of Residues in the environment**
  The primary source of environmental pollution by pesticides, insecticides, and metallic toxins is the residue left after their application in agriculture and public health pest control. A significant portion of these chemicals does not immediately enter living organisms but remains in soil, water, and air. These residues can undergo transformations, be transported to different locations, and eventually be absorbed by various organisms in the ecosystem.

Toxicity Mechanisms and Health Impacts of Pesticides

Although pesticides are intended to manage pests, they can also be harmful to unintended organisms, including humans. This is because many biological systems, such as enzymes, hormones, and biochemical pathways, are shared across different species, from insects to humans. Improper pesticide application can lead to residues in food, posing significant health risks to consumers. The risks associated with pesticide use in agriculture can be categorized into three distinct but interconnected concerns:

1. Environmental Risks – Pesticides can negatively impact non-target organisms and contaminate groundwater, leading to ecological imbalances.
2. Occupational Risks – Agricultural workers and employees in pesticide manufacturing facilities face the highest levels of exposure, making them the most vulnerable to pesticide-related health concerns.
3. Food Contamination – Pesticide residues in or on food products can contribute to chronic health conditions in consumers over time.

Health Effects of Pesticide Exposure

Exposure to pesticides has been linked to a range of health issues, including:

- Cancer – Increased risk of various types of cancers due to prolonged exposure.
- Respiratory Diseases – Conditions such as asthma and chronic bronchitis may develop or worsen.
- Depression – Pesticides have been associated with neurological effects, potentially leading to mental health issues.
- Behavioral Changes – Exposure may contribute to cognitive impairments and mood disorders.
- Immunosuppression – A weakened immune system increases susceptibility to infections and diseases.
- Women-Specific Disorders – Hormonal disruptions can contribute to reproductive health issues.
- Diabetes – Certain pesticides have been linked to an increased risk of developing metabolic disorders, including diabetes.

Symptoms of Insecticide and Pesticide poisoning in humans

Systems	**Examination**	**Signs of Toxicity**
Central nervous system and somatomotor	▪ Body movements ▪ Muscular tone	▪ Twitch, tremor, ataxia, convulsion, paralysis, fasciculation ▪ Rigidity, flaccidity

	▪ Clinical signs	▪ Headache, disturbed dreams and poor sleep, perspiration, nervousness, dizziness, test on reflex
Autonomic	▪ Pupil size ▪ Secretion	▪ Myosis, mydriasis ▪ Salivation, lacrimation
Respiratory	▪ Nostrils ▪ Character of breathing ▪ Clinical signs	▪ Unusual discharge or movements, rhinorrhea ▪ Bradypnea, dyspnea, yawning ▪ Constriction of chest, cough, and wheezing
Ocular	▪ Eyelids and eyeball ▪ Clinical signs	▪ Ptosis, exophthalmos ▪ Pain on accommodation, dimness, lacrimation, conjunctival injection
Gastrointestinal	▪ Clinical signs	▪ Anorexia, nausea, vomiting, diarrhea
General side effects	▪ Acute poisoning ▪ Chronic poisoning	▪ Temperature, skin texture and color, cardiovascular effects, cyanosis, jaundice ▪ Food intake, body weight, tumor, disease, sleep time

3.1 Preventive measures and methods of removal

Prevention

- Apply pesticides only when their advantages exceed the potential risks.
- Refrain from using pesticides for aesthetic purposes or on a routine schedule in households.
- Implement integrated pest management (IPM) strategies and opt for non-chemical methods to control pests.

If pesticide use is necessary:

- Keep pesticides in their original containers with child-resistant seals, stored securely out of children's reach in a locked cabinet.
- Provide education on the proper and safe application of pesticides.

- Adhere strictly to the manufacturer’s guidelines for use.
- Wear appropriate protective gear when handling pesticides.
- Observe recommended re-entry intervals after application.
- Pregnant women should avoid applying pesticides.
- Opt for the least hazardous chemicals and the safest application methods.

Organizations such as FAO and WHO advocate for alternative, non-chemical pest control methods. There is growing support for pesticide-free agriculture and integrated pest management (IPM). Various community-led initiatives contribute to reducing pesticide reliance in homes, schools, public spaces, healthcare facilities, and parks.

Integrated Pest Management (IPM)

IPM is an environmentally conscious strategy for managing pests, including animals and weeds, by applying multidisciplinary knowledge of crop-pest interactions, setting economic thresholds for pest populations, and continuously monitoring fields for potential issues. This approach incorporates various techniques such as:

- Utilizing pest-resistant crop varieties
- Practicing crop rotation
- Implementing cultural control methods
- Maximizing the use of biological control agents
- Using certified seeds and protective seed treatments
- Ensuring disease-free transplants or rootstock
- Timing crop cultivation effectively
- Optimizing pesticide application schedules
- Removing or plowing under infested plant material

Removal of Contaminants

To minimize chemical contamination in food, it is essential to develop effective removal methods that eliminate pollutants from the environment, thereby reducing the risk of food contamination. Traditional removal techniques include incineration, solvent extraction, gas-phase chemical reduction, alkali metal reduction, and landfilling.

Bioremediation

An eco-friendly alternative, bioremediation involves using microorganisms to break down pollutants, effectively detoxifying the environment without causing further harm.

3.7 Lets Sum up

This unit covered chemical, physical, and microbiological toxins, along with their effects on human health. The most effective way to prevent foodborne issues is to maintain strict hygiene standards throughout storage, packaging, processing, and marketing. Proper handling of food products is crucial to avoid container damage and exposure to contaminants. Additionally, by regulating chemical usage, we can minimize toxins and their adverse impacts.

3.8 Glossary

- **Food Contamination**: The presence of harmful microorganisms or chemicals in food that can lead to illness in consumers.
- **Bioremediation**: A process utilizing living or non-living biological systems to remove environmental pollutants from air, water, soil, industrial waste, and flue gases in both natural and controlled environments.
- **Microbial Toxins**: Poisonous substances produced by microorganisms such as bacteria and fungi.
- **Botulinum Neurotoxins (BoNTs)**: Highly toxic substances responsible for botulism, a severe foodborne illness. Due to their extreme toxicity and ease of production, they are considered a potential biological warfare threat.
- **Food Infection**: Illness caused by consuming food contaminated with harmful microorganisms.
- **Food Intoxication**: Sickness resulting from ingesting food that contains toxins produced by bacteria, mold, or other biological or chemical agents.
- **Toxin-Mediated Food Infection**: A condition where harmful microorganisms enter the body through contaminated food, multiply, and subsequently produce toxins that cause illness.
- **Toxin**: A harmful substance produced by bacteria, fungi, viruses, or other organisms, which can have detrimental effects on living beings.
- **Bacterial Toxins**: Poisonous substances generated by bacteria that can lead to various diseases and symptoms upon ingestion, inhalation, or contact with the body.
- **Endotoxin**: A toxin found in the outer membrane of certain bacteria, released upon bacterial death or disintegration, which can trigger immune responses, inflammation, and systemic effects.

- **Exotoxin**: A toxin actively secreted by bacteria into their surrounding environment during growth, often causing targeted damage to specific cells or tissues.
- **Enterotoxin**: A subset of exotoxins that specifically affect intestinal cells, leading to symptoms such as diarrhea, nausea, and vomiting, commonly linked to foodborne illnesses.
- **Neurotoxin**: A type of toxin that targets the nervous system, potentially causing paralysis, muscle weakness, or sensory disturbances.
- **Cytotoxin**: A toxic substance that damages or destroys cells by interfering with their normal functions or structure, affecting various types of tissues.
- **Mycotoxin**: Toxic compounds produced by molds (fungi) that can contaminate food and lead to serious health issues upon ingestion. Examples include aflatoxins, ochratoxin, and fumonisins.
- **Chemical Toxin**: A toxic compound not produced by microorganisms but capable of contaminating food and causing adverse health effects when consumed.
- **Foodborne Intoxication**: Illness resulting from consuming food tainted with toxic substances, such as chemicals or their derivatives. Unlike infections, intoxications do not involve microbial growth in the body.
- **Heavy Metals**: Metallic elements that accumulate in the environment and enter the food chain through industrial pollution, agriculture, or natural sources. Examples include lead, mercury, cadmium, and arsenic, which can cause chronic poisoning when ingested in high amounts.
- **Pesticide**: Chemical substances used to control pests like insects, weeds, and fungi in agriculture. Excessive residues or improper application can lead to contamination of food and potential toxicity when consumed.
- **Food Additives**: Substances incorporated into food during processing to enhance taste, texture, color, or shelf life. While generally safe, excessive consumption or sensitivity to certain additives may cause adverse reactions or toxic effects.
- **Environmental Contaminants**: Harmful pollutants from the environment that can enter the food chain and contaminate food. Examples include polychlorinated biphenyls (PCBs), dioxins, and polycyclic aromatic hydrocarbons (PAHs), which may pose health risks.
- **Shellfish Toxins**: Harmful substances produced by specific types of microscopic marine algae, accumulating in shellfish like clams, mussels, and oysters. Consumption of contaminated shellfish can result in various forms of poisoning, such as paralytic, amnesic, neurotoxic, or diarrheal shellfish poisoning, depending on the toxin involved.

Check Your Progress Exercises

Questions

1. List the primary sources of contamination and give two examples of each.

   ----

2. Describe two ways that insects androdents can damage or contaminate food.

   ----

3. Food safety is the practice of handling food in ways that prevent contamination or spoilage.

   True ------------------------ False ----------------------

4. Match the contaminant with the appropriate category: mould. bones, DDT, hair, viruses, Aflatoxin, PAHs

   I. Biological --
   II. Chemical --
   III. Physical --

5. What are microbial toxins, and how do they differ from chemical toxins?

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6. How do microbial toxins cause food intoxication?

   ----

7. What are the common sources of microbial toxins in food?

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8. How can microbial toxins be prevented or controlled in the food industry?

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9. What are some examples of microbial toxins that can cause foodborne illnesses?

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10. How do chemical toxins contaminate food, and what are their sources?

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11. What are the potential health risks associated with chemical toxins in food?

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12. How are chemical toxins regulated and monitored in the food industry?

UNIT - IV

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Overview

BLOCK-2 Food Safety Laws and Standards

Unit IV : Food Safety Laws and Standards

International Standards and Guidelines:

Provides an overview of international organizations, such as ISO mark for vegetarian and non-vegetarian foods, and their role in setting global food safety standards. Discusses key international standards and guidelines, such as the Codex Alimentarius Commission and its impact on national regulations.

National Food Safety Legislation:

Examines the role of national governments in establishing and enforcing food safety regulations like Food safety laws and standards: FSSAI, FPO, ISI, Agmark.

Provides examples of key legislation in various countries, such as the Food Safety Modernization Act (FSMA) in the United States and the Food Safety and Standards Act in India.

Unit -IV Food safety laws and standards Food packaging material

Structure

4.1 Introduction

Packaging plays a crucial role in the food manufacturing process, incorporating various additives such as antioxidants, stabilizers, lubricants, anti-static, and anti-blocking agents to enhance the functionality of polymeric packaging materials. However, recent findings indicate that packaging can act as a source of food contamination due to the migration of certain substances from the packaging into the food.

4.2 Potential Contaminants from Food Packaging Materials

Food packaging materials that may contribute to contamination include printed paperboard cartons, rigid plastic containers and lids, and glass jars or containers.

a.Ortho-phthalates

Commonly used in plastics and printing inks, these chemicals have been associated with endocrine disruption, as well as reproductive and developmental toxicity. Studies indicate that food contamination with phthalates is widespread. The U.S. FDA is currently reviewing the safety of these compounds.

b. Perchlorate

Utilized as an anti-static agent in plastics for dry food packaging and food handling equipment, perchlorate interferes with thyroid gland function, reducing thyroid hormone production essential for fetal and child brain development. Contamination in food is prevalent, with particularly concerning levels found in dry baby food cereals. The FDA is reassessing its safety.

c. Per- and Polyfluoroalkyl Substances (PFAS)

Used as grease-resistant coatings in paper packaging, PFAS are persistent chemicals that accumulate in the environment and have been linked to endocrine disruption and developmental issues in children. Since human exposure to PFAS is widespread through food and water, Washington State has enacted a ban on PFAS in food packaging, effective either in 2022 or two years after safer alternatives become available.

d. Benzophenone

Previously used as a plasticizer in rubber materials intended for repeated use, benzophenone has been classified as a carcinogen. Due to evidence of its harmful effects, the FDA has prohibited its use in flavoring agents and food packaging, with the ban taking effect in 2020.

e. Ethyl and Methyl Glycol, Toluene, and N-Methyl-Pyrrolidone (NMP)

These solvents, commonly found in printing inks, leave residue in packaging and pose risks of reproductive and developmental harm. Toluene and NMP have also been targeted for removal in other industries, such as personal care and beauty products. Major retailers, including Amazon and Rite Aid, have eliminated toluene from such products, while Home Depot, Lowe's, and Walmart have removed NMP from paint strippers. The U.S. Environmental Protection Agency (EPA) has proposed banning NMP in retail paint removers and is expected to finalize the regulation soon.

f. Bisphenol A, B, F, S

Used in the production of epoxy linings for metal cans, polycarbonate plastics, and printing inks, bisphenol compounds have been linked to endocrine disruption, as well as reproductive and developmental toxicity. BPA has already been banned in baby bottles and infant formula packaging. However, BPS, a common substitute for BPA, has been found to pose similar health risks.

g. Heavy Metals (Lead, Arsenic, Cadmium, Chromium VI, and Mercury)

These toxic metals are strictly regulated in various applications due to their harmful effects. Studies have revealed contamination of baby food with heavy metals, likely originating from food packaging materials, even though they are not intentionally added. The FDA's Toxic Elements Working Group is currently assessing children's exposure to heavy metals across all food categories.

4.3 Food safety laws and standards

4.3.1 FSSAI

Food Safety and Standards Authority of India (FSSAI)

The Food Safety and Standards Authority of India (FSSAI) is an independent statutory body responsible for ensuring food safety and setting food standards in India. It operates under the Ministry of Health & Family Welfare and is headquartered in New Delhi, with six regional offices located in Delhi, Guwahati, Mumbai, Kolkata, Cochin, and Chennai.FSSAI was established on 5 August 2011 by the Government of India, under the Food Safety and Standards Act, 2006. This Act serves as the legal foundation for food regulation in the country. The authority is composed of a Chairperson and 22 members and aims to create a unified food safety system, eliminating confusion among consumers, traders, manufacturers, and investors.

Food Safety and Standards Act, 2006

The Food Safety and Standards Act, 2006 was enacted to consolidate various laws related to food safety. It defines FSSAI's role in establishing science-based food standards, regulating food production, storage, distribution, sale, and import, and ensuring that food consumed by the public is safe and of high quality.

This Act replaced and combined several earlier laws and regulations, including:

- Prevention of Food Adulteration Act, 1954
- Fruit Products Order, 1955
- Meat Food Products Order, 1973
- Vegetable Oil Products (Control) Order, 1947
- Edible Oils Packaging (Regulation) Order, 1998
- Milk and Milk Products Order, 1992
- Essential Commodities Act, 1955
- The Solvent Extraction Oil, De-oiled Meal, and Edible Flour (Control) Order, 1967

Roles and Functions of FSSAI

FSSAI is responsible for regulating and supervising the manufacture, processing, distribution, sale, and import of food to ensure safety and quality. Its primary functions include:

- Setting Food Standards and Guidelines – Developing regulations and hygiene standards that all food manufacturers must comply with.
- Issuing Food Safety Licenses – Granting food business operators the required certification and licenses to ensure food quality compliance.
- Regulating Food Testing Laboratories – Establishing procedures for food testing, sampling, and analysis, as well as guidelines for accrediting laboratories.
- Conducting Inspections and Audits – Carrying out inspections of food production and processing units to ensure adherence to safety guidelines.
- Updating Food Labeling Standards – Defining labeling requirements, including nutritional claims, dietary information, and food categories.
- Raising Awareness About Food Safety – Educating the public on the importance of food hygiene and safety.
- Providing Training Programs – Offering training for individuals involved in food businesses to enhance food safety knowledge.
- Monitoring Food Contaminants – Collecting data on contaminants in food products and identifying emerging food safety risks.
- Maintaining Records and Data – Keeping track of all registered food businesses and ensuring compliance with regulations. Non-compliance can lead to license suspension.
- Updating the Government – Reporting any food safety threats to government authorities and assisting in policy development. FSSAI also enforces quality control measures for imported food products.

FSSAI Initiatives

The Food Safety and Standards Authority of India (FSSAI) has launched several key initiatives to uphold food safety and maintain quality standards across the country. Some of the significant initiatives include:

1. **Eat Right India** – Launched on July 10, 2018, this initiative aims to improve public health by addressing poor nutritional habits and tackling lifestyle diseases. It is a large-scale effort to transform India's food system, ensuring that all Indians have access to safe, healthy, and sustainable food. The movement is guided by the tagline "SahiBhojanBehtar Jeevan" and is centered around three core principles: Eat Safe, Eat Healthy, and Eat Sustainable.

2. **Clean Street Food** – This initiative focuses on educating and training street food vendors to ensure compliance with food safety regulations outlined in the FSS Act, 2006. It also aims to improve their social and economic conditions. The key objectives include:

   - Ensuring hygiene, safety, and quality standards in street food for consumers.
   - Supporting the economic and social growth of street vendors by helping them improve food quality, thereby attracting more customers.
   - Enhancing the global reputation of Indian street food by transforming it into a well-recognized and trusted brand.

3. **Food Safety Training and Certification (FoSTaC)**

The FoSTaC program is an extensive training initiative developed for food business operators (FBOs). According to regulations, every licensed food establishment (holding either a Central or State License) must have at least one certified food safety supervisor for every 25 food handlers or a fraction thereof across all its locations. Under FoSTaC, food safety supervisors receive formal training and certification to ensure compliance with food safety standards. The program currently offers 19 specialized courses across three levels—Basic, Advanced, and Special—with additional courses introduced post-COVID. FSSAI has implemented this initiative to provide a structured and accessible training system, ensuring that every food business has at least one trained and certified professional to uphold food safety standards.

4. **Detect Adulteration with Rapid Test (DART)** – The DART initiative by FSSAI aims to help consumers identify food adulteration at home. This initiative includes a manual that provides simple and quick tests to detect common adulterants in food items, ensuring safer consumption.
5. **Diet4Life**– This initiative is designed to raise awareness about metabolic disorders and educate the public on their prevention and management. It focuses on informing individuals about nutritional requirements for those affected by metabolic conditions, promoting better health outcomes.

6. **Food Safety on Wheels (FSW)** – To strengthen food testing infrastructure, FSSAI introduced Food Safety on Wheels, a mobile food testing initiative. This program enhances the availability of food testing services in both the public and private sectors. These mobile units are deployed to conduct on-the-spot testing, raising awareness about food safety and ensuring regulatory compliance.
7. **Save Food, Share Food, Share Joy** – This initiative seeks to reduce food wastage and encourage food donation. FSSAI aims to connect food collection agencies with food manufacturers and suppliers, ensuring that surplus food reaches those in need instead of being wasted. This initiative promotes social responsibility and helps in alleviating hunger.
8. **RUCO (Repurpose Used Cooking Oil)** – FSSAI has identified India's potential to recover 220 crore liters of used cooking oil for biodiesel production through a coordinated approach. Although the current biodiesel output from used cooking oil is minimal, a structured collection and conversion ecosystem is rapidly expanding. FSSAI is also working on regulatory measures to ensure that businesses using large amounts of cooking oil handover used oil to registered collection agencies for conversion into biofuel.

9.BHOG (Blissful Hygienic Offering to God)

Launched in 2018 by the Food Safety and Standards Authority of India (FSSAI), the BHOG initiative focuses on maintaining food safety and hygiene in Places of Worship (PoW), where food holds religious significance. As part of FSSAI's Safe and Nutritious Food (SNF) program, BHOG aims to ensure that food prepared and distributed in religious establishments meets hygiene standards.

The key objectives of the initiative include:

- Encouraging PoW to implement food safety and hygiene practices in the preparation, serving, and sale of food, along with providing training to food handlers.
- Identifying places of worship where food is cooked or handled, conducting audits, and offering basic hygiene training to food handlers.
- Granting official recognition and certification to places of worship that successfully meet the required hygiene and safety standards.

9. **Fruit Product Order (FPO), 1955**

   The Fruit Products Order (FPO), 1955, was introduced under Section 3 of the Essential Commodities Act, 1955, with the primary goal of ensuring the sanitary and hygienic production of fruit and vegetable-based products while maintaining quality standards outlined in the Order. It is compulsory for all manufacturers of fruit and vegetable products, as well as certain non-fruit items like non-fruit vinegar, syrup, and sweetened aerated water, to obtain a license under this regulation.

The FPO establishes minimum requirements to ensure hygienic production and product quality, which include:

Factory location and surroundings

Sanitary and hygienic conditions of the premises

Personal hygiene of workers

Availability of potable water

Machinery and equipment along with installed capacity

Quality control facilities and technical staff

Compliance with product standards

Limits on preservatives and other additives

The Ministry of Food Processing Industries is responsible for enforcing the FPO through the Directorate of Fruit & Vegetable Preservation, headquartered in New Delhi. The Directorate operates four regional offices in Delhi, Mumbai, Kolkata, and Chennai, along with sub-offices in Lucknow and Guwahati. Officials conduct regular inspections of manufacturing units, collecting random product samples from both manufacturers and markets, which are then tested in laboratories to ensure compliance with FPO standards.

The Central Fruit Advisory Committee, consisting of government officials, technical experts, and representatives from organizations such as the Central Food Technology Research Institute, Bureau of Indian Standards, and the fruit and vegetable processing industry, is responsible for suggesting amendments to the FPO. In response to industry demands and economic liberalization, significant modifications were made to the FPO in 1997.

Indian Standards Institution (ISI) and Bureau of Indian Standards (BIS)

The ISI mark has been a quality certification mark for industrial products in India since 1950. It signifies that a product complies with the Indian Standards (IS) set by the Bureau of Indian Standards (BIS), which serves as the national standards body of India.

The Bureau of Indian Standards (BIS) operates under the Department of Consumer Affairs, Ministry of Consumer Affairs, Food & Public Distribution, Government of India. It comprises 25 members representing Central and State Governments, industry, scientific and research institutions, and consumer organizations. The headquarters of BIS is located in New Delhi, with regional offices in Kolkata (East), Chennai (South), Mumbai (West), Chandigarh (North), and Delhi (Central), along with 20 branch offices. Additionally, BIS functions as India's WTO-TBT (World Trade

Organization - Technical Barriers to Trade) enquiry point. It was formally established on December 23, 1986, with its head office in New Delhi.

Key Functions of BIS:

- Developing standards and guidelines for various products
- Ensuring product quality and safety
- Monitoring food product safety through mandatory certification
- Providing product certification
- Granting quality system certification
- Serving as India's contact point for WTO-related matters

Products Requiring Mandatory BIS Certification:

1. Infant formula (IS 14433)
2. Milk cereal-based weaning food (IS 1656)
3. Processed cereal-based weaning food (IS 11536)
4. Follow-up formula (IS 15757)
5. Packaged drinking water (IS 14543)
6. Packaged mineral water (IS 13428)
7. Milk powder (IS 1165)
8. Skimmed milk powder (IS 13334)
9. Partly skimmed milk powder (IS 14542)
10. Condensed milk, partly skimmed and skimmed condensed milk (IS 1166)

AGMARK: Agricultural Marketing Certification

AGMARK is a certification mark in India that ensures agricultural products meet established quality standards. It is legally enforced under the Agricultural Produce Act, 1937, which was later amended in 1986. The head office is located in Faridabad, Haryana.

Key Functions of AGMARK:

- Post-harvest grading system for agricultural produce
- Issuing product quality certification
- Ensuring product safety for consumers
- Maintaining a network of quality control laboratories
- Ensuring the quality of imported agricultural products
- Supporting fair-trade practices and assisting in marketing

AGMARK Laboratories and Certification Process:

AGMARK certification is implemented by state-owned laboratories across India, which function as testing and certifying centers. The Directorate of Marketing and Inspection, an agency of the Government of India, oversees the certification process.

The Central AGMARK Laboratory (CAL) is located in Nagpur, along with 11 Regional AGMARK Laboratories (RALs) in key cities including Mumbai, New Delhi, Chennai, Kolkata, Kanpur, Kochi, Guntur, Amritsar, Jaipur, Rajkot, and Bhopal. Each regional laboratory is equipped to test and certify agricultural products relevant to its region, ensuring that the certification process is tailored to local agricultural needs.

4.3.2 CODEX ALIMENTARIUS COMMISSION

Codex Alimentarius Commission (CAC)

The Codex Alimentarius Commission (CAC) is an intergovernmental organization established in 1963 with the primary goal of developing international food standards to protect consumer health and facilitate global trade in food and agricultural products. Its headquarters is located in Rome, Italy.

As of 2017, CAC had 189 members, comprising 187 countries and one Member Organization (European Community). India is a member through the Ministry of Health and Family Welfare.

Role and Significance of Codex Alimentarius

The CAC serves as the most recognized international reference for food standards. It publishes the Codex Alimentarius, or "Food Code", which is a compilation of internationally accepted food standards. This document includes:

- Standards
- Codes of Practice
- Guidelines
- Recommendations

These components ensure consumer protection and fair practices in global food trade. Many nations adopt Codex Standards as a basis for their domestic food regulations.

The Food and Agriculture Organization (FAO) and the World Health Organization (WHO) collaborate to provide neutral and scientific guidance for formulating international food safety standards, supporting the development of modern food control systems at the national level.

Mechanisms for the Provision of Scientific Advice

FAO and WHO provide scientific advice related to food safety and nutrition through different mechanisms, expert bodies and meetings, and ad hoc consultations:

- The Joint FAO/WHO Expert Committee on Food Additives (JECFA) (active since 1956)
- The Joint FAO/WHO Meetings on Pesticide Residues (JMPR) (active since 1963)
- The Joint FAO/WHO Expert Meetings on Microbiological Risk Assessment (JEMRA) (active since 2000)
- The Joint FAO/WHO Expert Meetings on Pesticide Specifications (JMPS) (active since 2002)
- The Joint FAO/WHO Expert Meeting on Nutrition (JEMNU)

4.3.3 INTERNATIONAL ORGANISATION FOR STANDARDISATION (ISO)

The International Organization for Standardization (ISO) is a global, non-governmental federation comprising national standards bodies from 164 member countries. ISO's primary objective is to promote standardization and related activities to facilitate international trade and foster cooperation in scientific, technological, intellectual, and economic domains.

As an independent international entity, ISO brings together experts from various fields to develop voluntary, consensus-driven international standards that encourage innovation and offer solutions to global challenges. These international standards establish world-class specifications for products, services, and systems, ensuring their quality, safety, and efficiency. They play a crucial role in simplifying global trade by making products and services reliable, consistent, and of high quality.

For businesses, ISO standards serve as strategic tools that help reduce costs by minimizing errors and waste while enhancing productivity. They also provide companies access to new markets, create a level playing field for developing countries, and promote free and fair trade worldwide.

ISO has published 22,598 international standards and related documents, covering various industries, including technology, food safety, agriculture, and healthcare. The organization was established in 1946, following a meeting of delegates from 25 countries in London. ISO officially commenced operations on

February 23, 1947, with the goal of coordinating and unifying industrial standards at an international level. The outcomes of ISO's efforts are international agreements, which are then published as International Standards.

One of the key ISO standards, ISO 9000, serves as a global benchmark for quality management, focusing on organizational quality assurance. Adopting ISO standards is voluntary, but they help ensure fair business practices, consistency in food labelling and claims, and a harmonized global food supply chain.

This document outlines the technical criteria for food and beverage products suitable for vegetarians (including ovo-lacto, ovo, and lacto-vegetarians) and vegans at a global level. It applies to all food and beverage companies, irrespective of their size or complexity, and is intended to be used in business-to-business communications, international food trade, and food labelling regulations.

By adhering to these standards, companies ensure fair trade practices, consistency in food labelling, and equal opportunities in global food supply chains.

A vegetarian diet is defined as one that:

1. Primarily consists of ingredients derived from multi-cellular plants, fungi, algae, and bacteria.
2. May include honey, dairy products (produced without slaughter by-products), and/or unfertilized eggs obtained from live animals.
3. Excludes all forms of animal flesh and any products derived from animal slaughter, such as gelatin, animal fats, caviar, and roe.

A strict vegetarian diet, also referred to as a vegan diet, excludes all ingredients and additives of animal origin.

Claims

When labelling a food product as suitable for vegetarians, it should specify the category of vegetarianism by using one or more of the following prefixes before the term 'vegetarian':

(a) Lacto (milk) – Indicates that milk and dairy products are included, but excludes products prepared using animal rennet.
(b) Ovo (egg) – Signifies that unfertilized eggs (preferably free-range) and egg-based products are included.
(c) Honey – Denotes the inclusion of honey.

(d) Strict vegetarian or vegan – Means that ingredients derived from multi-cellular plants, fungi, algae, and bacteria are included, while all ingredients and additives of animal origin are completely excluded.

If a food product is labeled as 'strict vegetarian' or 'vegan', and the name of an ingredient or additive does not clearly indicate whether it is of non-vegetarian origin, its non-vegetarian source must be explicitly stated. This should be done by mentioning 'non-vegetarian origin' or specifying the source in parentheses after the name of the additive or ingredient.

Let's sum up

In this unit, you explored the different types of contaminants and their sources in detail. Additionally, we examined various organizations, their objectives, and the benefits they offer in ensuring food safety and quality assurance, ultimately contributing to the well-being of consumers.

4.4 Glossary

Food contamination-Food contamination refers to the spoilage or tainting of food due to the presence of microorganisms like bacteria or parasites, or harmful substances, rendering it unsafe for consumption

FSSAI-Food Safety and Standards Authority of India

- Lacto (milk): Includes milk and dairy products, but excludes those prepared using animal rennet.
- Ovo (egg): Comprises unfertilized eggs (preferably free-range) and egg-based products.
- Honey: Includes honey as part of the diet.
- Strict vegetarian or vegan: Consists of ingredients derived from multicellular plants, fungi, algae, and bacteria while completely excluding all animal-derived ingredients and additives.
- Vegetarian: Refers to a diet that:
    1. Primarily consists of ingredients from multicellular plants, fungi, algae, and bacteria.
    2. May include honey, dairy products made without slaughter by-products, and unfertilized eggs from live animals.
    3. Excludes all types of animal flesh and by-products obtained from slaughter, such as gelatin, animal fats, caviar, and roe.

JECFA-Joint FAO/WHO Expert Committee on Food Additives

4.5 Check Your Progress Exercise

(i) FSSAI stands for-

(ii) What are the contaminants from food packaging.

(iii) CODEX stated in -------------- and its headquarter is situated in--------------------.

(iv) How many acts were repealed in FSSAI.

(v) The definition of Strict vegetarian diet'
