UNIT 5

Food safety and Ethics

Food safety is a scientific discipline describing handling, preparation, and storage of food in ways that prevent food borne.

Importances of food safety and hygiene

- Prevent food spoilage, i.e. changes that make food unfit for consumption due to microbial or chemical contamination.
- Inform and educate people about simple and practical methods of keeping food safe to protect themselves against foodborne diseases.
- Protect food from adulteration (intentional contamination).
- Ensure proper practice in the food trade to prevent the sale of food that is offensive or defective in value and quality

Food hazards

Food hazards refer to any biological, chemical, or physical agent in food that may cause harm to the consumer. It's crucial to identify and manage these hazards to ensure the safety and quality of the food supply. Here are the main types of food hazards:

Biological Hazards:

Bacteria: Pathogenic bacteria such as Salmonella, Escherichia coli (E. coli), Listeria, and Campylobacter can cause foodborne illnesses.

Viruses: Norovirus, Hepatitis A, and other viruses can contaminate food, especially through contact with infected food handlers.

Parasites: Protozoa, roundworms, and flatworms are examples of parasites that can be transmitted through contaminated food or water.

Chemical Hazards:

Chemical contaminants: Pesticides, herbicides, and other agricultural chemicals can be present in or on food if not properly monitored.

Food additives: While many food additives are safe, improper use or contamination can pose risks. Examples include artificial colors, preservatives, and flavor enhancers.

Toxins: Some naturally occurring substances, such as mycotoxins (produced by fungi), marine toxins, and plant toxins, can contaminate food.

The examples of the chemicals hazards are indicated.

Table 2.3: Types of chemical hazards

Food Borne Toxicants		
Naturally Occurring Chemicals	**Unintentional Chemicals**	**Intentional Chemicals**
Found in plants, microorganisms and animals e.g. mycotoxins, histamine, mushroom toxins, shellfish toxins etc.	Lead, Polychlorinated biphenyls (PCBs) and paralysis products etc.	Food additives, pesticides, drugs

Physical Hazards:

Physical hazards include a variety of materials often referred to as extraneous materials. It may be defined as any foreign material not normally found in a food, which may cause illness or injury to the individuals consuming/using the product. They may cause injury, illness and others may never be noticed.

Foreign objects: Physical contaminants like glass, metal, plastic, or wood can accidentally get into food during processing, handling, or packaging.

Allergens: Ingredients that can cause allergic reactions in some individuals (e.g., nuts, shellfish, gluten) need to be clearly labeled to prevent unintentional exposure.

Few of visible physical hazards are highlighted in Table 2.1

Table 2.1: Hazards associated with food

Physical	Biological	Chemical		Allergens
		Natural occurring poisons of biological origin	Chemicals or deleterious substances	
Glass Hair Metal Stones Plastic Parts of pests Insulation material Bone Fruit pits	Microbiological Pathogenic Bacteria • Spore-forming • Non spore-forming Parasites and protozoa Viruses	Mycotoxins, Algal toxins	Veterinary residues, Antibiotics Growth stimulants Plasticisers and packaging material Chemical Residues Pesticides Cleaning fluids, Allergens Toxic metals, Lead and cadmium, Food chemicals preservatives, processing aids, polychlorinated biphenyls (PCBs), printing inks, prohibited	Cereals containing gluten; i.e wheat, barely, oats etc. Crustaceans and product of these Eggs and egg products fish and fish products Peanuts,soyabean and products of these; Milk and milk products.

Allergenic Hazards:

Certain foods and food ingredients can cause allergic reactions in susceptible individuals. Cross-contamination and mislabeling are common causes of allergen-related incidents. Food allergy symptoms include: wheezing or breathing problems, stomach cramps, vomiting, diarrhea, hives, rashes or eczema, whereas, severe allergic reactions can cause death.

A food allergy occurs when the immune system:

- Identifies a particular food protein as danegerous and create antibodies against it.
- The next time the individual eats that food, immune system tries to protect the body against the danger by releasing massive amount of chemicals including Histamine.
- Histamine is a powerful chemical that can cause a reaction in the respiratory system, gasterointestinal tract, skin or cardiovascular system.
- In the most extreme cases, food allergy can be fatal. Although any food can provoke an immune response in allergic individuals, a few foods are responsible for the majority of food allergies.

Radiological Hazards:

Contamination with radioactive substances can occur, especially in certain types of fish or in areas with nuclear incidents.

Preventing and managing food hazards involve implementing good manufacturing practices (GMP), Hazard Analysis and Critical Control Points (HACCP), and other food safety management systems. Regular inspections, testing, and proper labeling are also essential components of ensuring food safety. Consumers can contribute to their safety by practicing proper food handling, cooking, and storage at home. Public health agencies and regulatory bodies play a crucial role in monitoring and enforcing food safety standards to protect the public.

Food additives

Food additives are substances added to food products during processing or preparation to enhance their quality, appearance, taste, texture, or shelf life. These additives serve various purposes and are categorized based on their functions. Here are some common types of food additives:

Preservatives: These additives help prevent spoilage and extend the shelf life of food by inhibiting the growth of bacteria, molds, and yeasts. Examples include sodium benzoate, potassium sorbate, and nitrites.

Antioxidants: Antioxidants are added to food to prevent or slow down the oxidation process, which can lead to rancidity and color changes. Common antioxidants include vitamin C (ascorbic acid) and vitamin E (tocopherols).

Colorings: Food colorings are used to enhance or restore the color of food products. They can be natural, derived from plants and minerals, or synthetic. Examples include beet juice (natural) and tartrazine (synthetic).

Flavorings: Flavor enhancers are added to food to improve or modify its taste. These can be natural, such as herbs and spices, or synthetic, like monosodium glutamate (MSG).

Emulsifiers: Emulsifying agents help mix substances that would normally separate, such as oil and water. Common emulsifiers include lecithin and mono- and diglycerides.

Stabilizers and Thickeners: These additives help maintain the texture and consistency of food products. Examples include agar-agar, carrageenan, and xanthan gum.

Sweeteners: Sweeteners are used to add sweetness to food and beverages. They can be natural, like honey and maple syrup, or artificial, such as aspartame and saccharin.

Acidity Regulators: These additives control the acidity or alkalinity of food products. Citric acid and sodium bicarbonate are examples of acidity regulators.

Anti-caking Agents: Anti-caking agents prevent the formation of lumps or clumps in powdered or granulated substances. Silicon dioxide and calcium silicate are common anti-caking agents.

It's important to note that food additives undergo strict safety evaluations before being approved for use in food products. Regulatory agencies, such as the Food and Drug Administration (FDA) in the United States and the European Food Safety Authority (EFSA) in Europe, set guidelines and maximum allowable levels for these additives to ensure consumer safety.

Food allergens

Food allergy is an abnormal response to a food triggered by the body's immune system. Allergic reactions to food can cause serious illness or even death. Food allergens are proteins within the food that enter our bloodstream after the food is digested. Food allergen go to target organs such as skin, nose, etc and cause allergic reactions. An allergic reaction to food can take place within few minutes to an hour

Food intolerance

- An abnormal physiological response to eating
- Food intolerance is caused by the lack of our body's ability to digest certain substances.
- Some people may have a food intolerance that has a psychological trigger.

Food allergy is different with food intolerance although both can show similar symptoms.

Types of food allergies

IgE mediated food allergy

- Reactions occur when allergens bind to Immunoglobulin E (IgE) antibodies bound to mast cells, resulting in the release of histamine and other inflammatory mediators.
- Symptoms are usually of rapid onset (<30 minutes in children, usually <2 hours in adults). Diagnostic tests (e.g. skin prick and blood tests) are usually positive.

Non IgE mediated food allergy.

- Reactions occur when the ingested food protein causes an immune response resulting in delayed
- normally in the skin or gastrointestinal tract.
- Symptoms usually occur 2-24 hours after ingestion of the food protein.

- Diagnostic tests are usually negative. There is no definitive invitro test for non-IgE mediated food allergies.
- Mixed IgE and non IgE symptom clusters (of the above) can occur.
- Non IgE mediated can convert to IgE mediated allergy and therefore long term follow up is essential

Food Intolerance are as follows

- Food poisoning:
- Histamine toxicity
- Lactose intolerance
- Food additives, such as: MSG and Sulfites

An immediate allergic reaction involves two actions of our immune system:

1. Our immune system produces immunoglobulin E (IgE) – a type of protein that works against a specific food – antibody.
2. IgE attaches basophils (white blood cells) and to mast cells – cells found in all body tissues. The typical sites of allergic reactions include nose, throat, lungs, skin and GI tract.

Common symptoms of food allergies include hives, itching, swelling, abdominal pain, nausea, vomiting, difficulty breathing, and anaphylaxis, which is a severe and potentially life-threatening reaction.

Note: Anaphylaxis is a severe and systemic allergic reaction. It usually occurs soon after exposure to the specific allergen but can occasionally take a few hours to develop.

Here are some common food allergens:

Milk: Allergies to cow's milk are common, especially in children. People with a milk allergy need to avoid not only milk but also dairy products and foods containing hidden milk ingredients.

Eggs: Egg allergies are more common in children, and reactions can range from mild to severe. Both the egg white and yolk can cause allergic reactions.

Peanuts: Peanut allergies are often lifelong and can cause severe reactions. Even small amounts of peanuts or peanut products can trigger an allergic response.

Tree Nuts: This category includes various nuts, such as almonds, walnuts, cashews, pistachios, and others. Tree nut allergies can also be severe and are often lifelong.

Soy: Soy allergies are more common in children and can cause a range of symptoms. Soy is present in many processed foods, so it's important for individuals with soy allergies to carefully read labels.

Wheat: Wheat allergies can cause allergic reactions, but they are different from gluten intolerance or celiac disease. People with wheat allergies need to avoid wheat-containing products.

Fish: Allergies to fish, including species like salmon, tuna, and cod, can cause severe reactions. It's important to note that fish is different from shellfish.

Shellfish: This category includes crustaceans (e.g., shrimp, crab, lobster) and mollusks (e.g., clams, mussels, oysters). Shellfish allergies can be particularly severe.

Sesame: Sesame allergies are becoming more recognized as a significant allergen. Sesame is used in various foods, so individuals with this allergy need to be vigilant about checking ingredient labels.

Sulfites: While not a food itself, sulfites are chemicals used as preservatives in certain foods and beverages. Some people may be sensitive or allergic to sulfites.

It's important for individuals with food allergies to carefully read ingredient labels, communicate their dietary needs to restaurant staff, and be prepared with appropriate medications.

Drugs, Hormones, and Antibiotics in Animals

The use of drugs, hormones, and antibiotics in animals is a complex and controversial issue with implications for animal health, human health, and environmental sustainability.

Drugs:

Purpose: Drugs may be administered to animals for various reasons, such as treating illnesses, preventing diseases, or promoting growth.

Concerns: Overuse or misuse of drugs can lead to the development of antibiotic-resistant strains of bacteria, posing a threat to both animal and human health. Additionally, residues of certain drugs may be present in animal products, potentially affecting consumers.

Chemicals such as pesticides, antibiotics and hormones are used in plant and animal farming to boost production, reduce food waste and ensure adequate food supply. **Food Standards Australia New Zealand (FSANZ)** sets the maximum allowed limits for agricultural and veterinary chemical residues present in foods in Australia (both domestic and imported foods). The use of pesticides can dramatically increase crop production and ensure a higher quality of produce. However, pesticides are also toxic chemicals designed to kill agricultural pests, and some can cause problems if they are consumed by humans in large amounts.

In animal farming, drugs such as antibiotics and hormones are used to boost growth and cut down on feed requirements. Residues of these drugs can also be hazardous to humans. The level of harm from exposure to pesticides, animal antibiotics and hormones is dose related, meaning the more you consume, the greater the potential risk.

Reducing our exposure to pesticides and other chemicals in food - To reduce your exposure to pesticides and other chemicals:

- Buy organic produce.
- Thoroughly wash all fruit and vegetables (even organic).
- Grow your own vegetables.
- Peel vegetables or remove the outer layer of leaves.
- Trim visible fat from meats – as many residues are fat soluble.
- Cook meat and chicken thoroughly.

Consume a variety of foods (including meat alternatives like legumes, tofu, nuts and eggs) to reduce your intake of antibiotic-resistant bacteria, hormones and pesticides.

Hormones:

Purpose: Hormones may be used in livestock production to promote growth, improve feed efficiency, and increase reproductive efficiency.

Concerns: The use of hormones in animal agriculture is a subject of debate. Some argue that it can lead to residues in meat and milk, while others express concerns about potential health effects on consumers. Regulatory bodies in various countries establish guidelines and limits for hormone use in animal agriculture.

Sex hormones (such as oestrogen and testosterone), are used in cattle to accelerate weight gain so they can be sent to market earlier. They have been widely used in the Australian beef industry for over 30 years. The use of hormones is highly regulated by the Australian Pesticides and Veterinary Medicines Authority (APVMA), which ensures they are safe for consumers and not harmful to animals.

Although unlikely in Australia due to our tight regulations, eating meat that contains unacceptably high levels of hormones can lead to many side effects in people (including breast enlargement and ovarian cysts).

Food Safety and Standards Authority of India (FSSAI) has stated that allergic reactions and long-term resistance to antibiotics found in humans are caused by drug residues in animal products like muscle, liver, kidney and milk. The FSSAI has insisted that packaged frozen and live products be tested before being sent to the market. These products are suspected to contain residues of medicines that are meant for human consumption, pesticides and veterinary drugs. The US FDA has listed the chemicals which are found in animal products and stated that each country must work towards controlling them. With the food industry in India growing at 17 per cent, the FSSAI wants laboratory tests conducted on animal products by the organised food sector; products from the unorganised sector must be randomly tested by state food inspectors. The chemicals that have been listed as drug residues of veterinary antibiotics are cholramphenicol and beta lactams. Pesticide residues like organophosphates, carbamates, chlorinated hydrocarbons and prethroids are also found in animal products.

Antibiotics:

Purpose: Antibiotics are often used in animal agriculture for disease prevention and treatment, as well as to promote growth.

Concerns: Similar to human medicine, the overuse of antibiotics in animals contributes to the emergence of antibiotic-resistant bacteria. This poses a significant public health threat as antibiotic resistance can compromise the effectiveness of these drugs in treating infections in humans.

Population growth and globalization are currently having many negative effects on the agri-food sector’s ability to ensure safe and qualitative food. Use of medicines and chemicals in animal husbandry can considerably increases production and animals’ resistance to disease and pests. Elevated levels of exposure to food contaminated with chemical residues from the use of antibiotics in animal husbandry and various growth hormones are very dangerous to human

health. They contribute to genetic changes at the cellular level and decreased resistance of the body to viruses and bacteria. Frequent use of antibiotics may result in chemical residues in milk, meat, eggs and honey due to large-scale application of drugs in veterinary practice. In addition to its toxicity, antibiotic residues are carcinogenic and ingested in the long term lead to increased tolerance to medication against human diseases caused by deadly bacteria. Continuous monitoring of the production phase of the agri-food chain is absolutely necessary to identify the risks of contamination and reduce the use of illegal antibiotics in animal husbandry

Antibiotics are medicines farmers can use (with veterinary supervision) to:

- Treat sick animals
- Prevent disease in animals and fruit crops
- Manage disease
- Promote growth (in some animals)

Antibiotics are approved for use in beef, dairy cattle, chickens, laying hens, turkeys, pork and fish. They may also be sprayed on fruit and given to honeybees. All antibiotics used must meet Health Canada's standards for human and animal safety.

The Challenge

Antibiotics are one of the most important tools in modern medicine. These drugs can mean the difference between life and death when humans contract a bacterial infection—from staph to salmonella to bacterial pneumonia. But overuse and misuse of these drugs are making bacteria more quickly resistant to essential antibiotics.

Antibiotic resistance complicates medical treatment, and frequently results in longer, more serious illnesses, and even death in some instances. Resistant bacterial infections are harder to treat, and require multiple applications of antibiotics, longer hospital stays and possibly other interventions. Children, the elderly and the chronically ill are particularly vulnerable to antibiotic-resistant infections. For these reasons, the Centers for Disease Control and Prevention (CDC) has declared that antibiotic resistance is among its top concerns.

The Solution

The improving management of food animals (for example, cleaning facilities more thoroughly and frequently) achieves the same benefits as routine use of antibiotics in healthy animals, without undermining the integrity of the antibiotic medicines we rely on to protect public health.

The FDA recommended to the U.S. Congress in 2009 that "to avoid unnecessary development of resistance under conditions of constant exposure (growth promotion/feed efficiency) to antibiotics, the use of antimicrobials should be limited to those situations where human health and animal health are protected. Purposes other than for the advancement of animal or human health should not be considered judicious use. Eliminating these uses will not compromise the safety of food."

Working together, citizens, government, industry and public interest organizations have the tools to reduce the overuse and misuse of antibiotics:

Individuals can practice safe and effective use of antibiotics by only taking them when and as prescribed by a doctor.

The food animal industry can adopt cost-effective alternative hygienic strategies for preventing illness in animals and discontinue use of antibiotics in feed for growth promotion and feed efficiency.

There are alternative methods to raising food animals on industrial farms that do not risk eroding the effectiveness of antibiotics.

The USDA acknowledged in a January 2009 report that the presumed economic and production benefits of antibiotics in animal feed can be largely achieved by improved cleanliness of animal houses and improved testing for diseases.

The WHO reported in 2000 that antibiotics should "not be used as an alternative to high-quality animal hygiene. Evidence shows that farmers who stopped relying on antimicrobials as growth promoters in livestock have experienced no economic repercussions—provided animals were given enough space, clean water, and high-grade feed."

The National Academy of Sciences reviewed meat consumption based on 1997 figures to determine the cost of removing the routine use of antibiotics in food animals. The results showed that on the high end of the assumptions, every person would pay $9.72 more per year for the meat they purchase.

Factors to reduce the use of drugs, hormones, and antibiotics in animals

Regulations and Guidelines:

Different countries have varying regulations regarding the use of drugs, hormones, and antibiotics in animals. Regulatory agencies, such as the U.S. Food and Drug Administration (FDA) and the European Medicines Agency (EMA), establish guidelines and monitor compliance in an effort to ensure the safety of animal products for human consumption.

Alternatives and Sustainable Practices:

There is growing interest in alternative and sustainable practices in animal agriculture. This includes organic farming, pasture-raised systems, and reduced reliance on antibiotics and hormones. These approaches aim to promote animal welfare, reduce environmental impact, and produce food products with fewer chemical residues.

Research and Innovation:

Ongoing research focuses on developing alternatives to traditional drug and hormone use in animal agriculture. This includes exploring probiotics, prebiotics, and vaccines as alternatives to antibiotics, as well as investigating more sustainable and ethical methods of promoting animal growth and health.

Overall, the use of drugs, hormones, and antibiotics in animals is a complex issue that requires a balanced approach to address concerns related to human health, animal welfare, and environmental sustainability. Public awareness, research, and regulatory measures play crucial roles in shaping the future of animal agriculture practices.

Food Safety Regulations –

An Approach to Food Safety

A basic food safety plan uses the HACCP method. HACCP stands for **hazard analysis critical control points.** HACCP was originally developed by NASA to make sure the food on their space flights was safe to eat. HACCP is not a complicated process; it just means that you have to first identify the various steps you must take when you prepare your menu items, then look for possible sources of contamination, and then find ways to control these sources. The HACCP approach HACCP is an approach to food safety that is systematic and preventive. It is recommended by the Codex Alimentarius Commission, the United Nations international standards organization for food safety. HACCP is used by most countries around the world and has been in use since the 1960s. HACCP goes beyond inspecting finished food products. It helps to find, correct, and prevent hazards throughout the production process. These include physical, chemical, and biological hazards. There are seven universally accepted HACCP principles. Every country that uses HACCP follows these principles.

Principle 1: Hazard analysis

A plan is laid out to identify all possible food safety hazards that could cause a product to be unsafe for consumption, and the measures that can be taken to control those hazards. For example, at the cooking step of the production process, one of the identified hazards is the survival of pathogens due to inadequate cooking time or temperature.

Principle 2: Identifying critical control points

Critical control points are the points in the production process where an action can be taken to prevent, eliminate, or reduce a food safety hazard to an acceptable level. For example, the cooking step is considered a critical control point because control measures are necessary to deal with the hazard of pathogens surviving the cooking process.

Principle 3: Establishing critical limits for each critical control point

A critical limit is the limit at which a hazard is acceptable without compromising food safety. For example, critical limits at the cooking stage include specific time and temperature for cooking the product.

Principle 4: Establishing monitoring procedures for critical control points

Highly detailed monitoring activities are essential to make sure the process continues to operate safely and within the critical limits at each critical control point. For example, monitoring procedures at a cooking critical control point could include taking the internal temperature of the product with a specialized thermometer.

Principle 5: Establishing corrective actions

Actions must be taken to bring the production process back on track if monitoring indicates that deviation from critical limits has occurred. In food production, correcting problems before end-stage production is far more effective than waiting until a product is finished to test it. For example: If the required internal temperature has not been reached, a corrective action would

require that the product be cooked further. If the cooking temperature cannot be reached, another corrective action would call for the product to be held and destroyed.

Principle 6: Establishing verification procedure

Verification means applying methods, procedures, tests, sampling and other evaluations (in addition to monitoring) to determine whether a control measure at a critical control point is or has been operating as intended. Verification activities also ensure that the monitoring and the corrective actions are done according to a company's written HACCP program. For example, testing and calibrating thermometers is a verification procedure that is important to ensure accurate readings. The easiest way to test a thermometer's accuracy is by submerging the probe into a pot of boiling water. If it does not read 100˚C (212˚F) then the thermometer must be adjusted to read the correct temperature.

Principle 7: Record keeping

The company must keep records to demonstrate the effective application of the critical control points and assist with official verification (which is done in Canada by the Canadian Food Inspection Agency). Records must be established to document the monitoring and verification results as well as all information and actions taken in response to any deviations found through monitoring and verification. For example, the employee responsible for monitoring a cooking critical control point completes a cooking log sheet. This sheet includes the date, the start and finish time, the temperature, and the employee's signature. If a deviation has occurred in the production process, the responsible employee records the details in a deviation log book.

Factors that contribute to foodborne illness

Foodborne illnesses, also known as food poisoning, can be caused by various factors. These illnesses result from the consumption of contaminated food or beverages. Several factors contribute to the occurrence and spread of foodborne illnesses:

Microbial Contamination:

Bacteria: Pathogenic bacteria like Salmonella, Escherichia coli (E. coli), Listeria, and Campylobacter are common culprits. These bacteria can multiply rapidly in certain conditions and produce toxins that cause illness.

Viruses: Norovirus, Hepatitis A, and rotavirus are examples of viruses that can contaminate food and cause illness.

Parasites: Protozoa, roundworms, and flatworms can contaminate food, especially undercooked meat and seafood.

Cross-Contamination:

Cross-contamination occurs when pathogens are transferred from one surface to another, such as from raw meat to vegetables or from hands to food. This can happen through shared cutting boards, utensils, or hands that have not been properly washed.

Improper Food Handling and Storage:

Poor hygiene practices during food preparation, inadequate cooking temperatures, and improper storage conditions can lead to the growth of harmful microorganisms. Perishable foods should be stored at appropriate temperatures to prevent bacterial growth.

Contaminated Water and Ice:

Water and ice can carry harmful pathogens if contaminated. Consuming food or drinks made with contaminated water or ice can lead to foodborne illnesses.

Inadequate Cooking or Heat Treatment:

Insufficient cooking temperatures may not kill pathogens present in food. It is crucial to cook food thoroughly, especially meat, poultry, and seafood, to eliminate harmful microorganisms.

Unsafe Sources:

Consuming raw or undercooked seafood, eggs, and meat poses a higher risk of foodborne illness. Unpasteurized milk and dairy products can also carry pathogens.

Inadequate Personal Hygiene:

Poor personal hygiene of food handlers, such as not washing hands properly, can introduce harmful bacteria and viruses into the food they handle.

Contaminated Equipment and Utensils:

Kitchen equipment and utensils, if not cleaned and sanitized properly, can be a source of contamination. Cutting boards, knives, and other utensils should be washed thoroughly to prevent cross-contamination.

Food from Unsafe Sources:

Food obtained from contaminated or unsanitary sources, such as street vendors with poor hygiene practices or unregulated food suppliers, can pose a risk of foodborne illness.

Inadequate Food Safety Practices:

Lack of awareness or adherence to proper food safety practices, both in households and food establishments, contributes to the occurrence of foodborne illnesses.

To prevent foodborne illnesses, it is essential to practice good hygiene, follow proper food handling and cooking procedures, and be vigilant about the sources and quality of the food consumed. Public health measures and regulations also play a crucial role in ensuring food safety.

Preventing Foodborne Illness

Food-handling and Storage Procedures

Proper food handling and storage can prevent most foodborne illnesses. In order for pathogens to grow in food, certain conditions must be present. By controlling the environment and conditions, even if potentially harmful bacteria are present in the unprepared or raw food, they will not be able to survive, grow, and multiply, causing illness.

There are six factors that affect bacterial growth, which can be referred to by the mnemonic FATTOM:

1. Food

2. Acid

3. Temperature

4. Time

5. Oxygen

6. Moisture

Each of these factors contributes to bacterial growth in the following ways:

• **Food:** Bacteria require food to survive. For this reason, moist, protein-rich foods are good potential sources of bacterial growth.

• Acid: Bacteria do not grow in acidic environments. This is why acidic foods like lemon juice and vinegar do not support the growth of bacteria and can be used as preservatives

• Temperature: Most bacteria will grow rapidly between 4°C and 60°C (40°F and 140°F). This is referred to as the **danger zone**

• Time: Bacteria require time to multiply. When small numbers of bacteria are present, the risk is usually low, but extended time with the right conditions will allow the bacteria to multiply and increase the risk of contamination

• Oxygen: There are two types of bacteria. **Aerobic bacteria** require oxygen to grow, so will not multiply in an oxygen-free environment such as a vacuum-packaged container. **Anaerobic bacteria** will only grow in oxygen-free environments. Food that has been improperly processed and then stored at room temperature can be at risk from anaerobic bacteria. A common example is a product containing harmful Clostridium botulinum (botulism-causing) bacteria that has been improperly processed during canning, and then is consumed without any further cooking or reheating.

• Moisture: Bacteria need moisture to survive and will grow rapidly in moist foods. This is why dry and salted foods are at lower risk of being hazardous.

Identifying Potentially Hazardous Foods (PHFs)

Foods that have the FATTOM conditions are considered **potentially hazardous foods (PHFs).** PHFs are those foods that are considered perishable. That is, they will spoil or "go bad" if left at room temperature. PHFs are foods that support the growth or survival of disease-causing bacteria (pathogens) or foods that may be contaminated by pathogens.

The Danger Zone

One of the most important factors to consider when handling food properly is temperature. Table 3 lists the most temperatures to be aware of when handling food.

Table 3. Important temperatures to remember

Celsius	Fahrenheit	What happens?
100°	212°	Water boils
60°	140°	Most pathogenic bacteria are destroyed. Keep hot foods above this temperature.
20°	68°	Food must be cooled from 60°C to 20°C (140°F to 68°F) within two hours or less
4°	40°	Food must be cooled from 20°C to 4°C (68°F to 40°F) within four hours or less
0°	32°	Water freezes
–18°	0°	Frozen food must be stored at −18°C (0°F) or below

The range of temperature from 4°C and 60°C (40°F and 140°F) is known as the danger zone, or the range at which most pathogenic bacteria will grow and multiply

Time-temperature Control of PHFs

Pathogen growth is controlled by a time-temperature relationship. To kill micro-organisms, food must be held at a sufficient temperature for a sufficient time. Cooking is a scheduled process in which each of a series of continuous temperature combinations can be equally effective. For example, when cooking a beef roast, the microbial lethality achieved at 121 minutes after it has reached an internal temperature of 54°C (130°F) is the same as if it were cooked for 3 minutes after it had reached 63°C (145°F).

Consumer Lifestyles and Demand

Consumer lifestyles and demand play a crucial role in shaping the business landscape across various industries. Understanding these factors is essential for businesses to develop effective marketing strategies, introduce relevant products and services, and stay competitive in the market.

Demographics:

- Age, gender, income, education, and occupation significantly influence consumer behavior and preferences.
- Businesses often tailor their products and marketing strategies to specific demographic segments.

Technological Influence:

- Rapid technological advancements impact consumer preferences and expectations.
- The adoption of new technologies can create demand for innovative products and services.

Social and Cultural Factors:

- Cultural trends, societal values, and lifestyle changes influence consumer choices.
- Businesses need to be aware of cultural shifts and adapt their offerings accordingly.

Economic Factors:

- Economic conditions, such as inflation, unemployment, and GDP growth, affect consumer purchasing power.
- During economic downturns, consumers may prioritize essential purchases over luxury items.

Environmental Sustainability:

- Growing awareness of environmental issues has led to increased demand for sustainable and eco-friendly products.
- Businesses that incorporate sustainable practices may gain a competitive edge.

Health and Wellness:

- Consumers are increasingly focused on health and wellness, leading to a demand for healthier food options, fitness products, and wellness services.
- Businesses can capitalize on this trend by offering products that promote a healthy lifestyle.

E-Commerce and Digitalization:

- The rise of e-commerce has transformed the way consumers shop, emphasizing the importance of online presence and convenient shopping experiences.
- Businesses need to adapt to digital trends to meet consumer expectations.

Personalization:

- Consumers appreciate personalized experiences, whether it's in product recommendations, marketing messages, or customer service.
- Businesses that can tailor their offerings to individual preferences are likely to succeed.

Globalization:

- Increased connectivity has exposed consumers to a variety of products and services from around the world.
- Businesses may need to consider global trends and adapt their strategies to cater to diverse consumer preferences.

Social Media Influence:

- Social media platforms play a significant role in shaping consumer opinions and trends.
- Businesses can leverage social media for marketing and engage with consumers to understand their needs better.

Understanding and adapting to these consumer lifestyle and demand trends are critical for businesses to stay relevant and meet the ever-changing expectations of their target audience. Continuous market research and flexibility in adapting to emerging trends are key elements of a successful business strategy.

Food Production and Economics

Food production and economics are closely intertwined, as the production and distribution of food have significant impacts on global economies, individual livelihoods, and overall well-

being. The following are key aspects provide relationship between food production and economics:

Agricultural Sector Contribution:

- The agricultural sector is a crucial component of many economies, especially in developing countries where a significant portion of the population relies on agriculture for their livelihoods.
- The contribution of agriculture to a country's GDP (Gross Domestic Product) varies, but it often plays a vital role in the overall economic health.

Employment Opportunities:

- Agriculture provides employment opportunities for a large portion of the global population, from small-scale family farms to larger commercial operations.
- Changes in food production practices and technology can impact the demand for labor, influencing rural employment rates.

Trade and Globalization:

Global food trade is a major aspect of the world economy. Many countries rely on importing and exporting food to meet their domestic needs and take advantage of comparative advantages.

Economic policies, trade agreements, and geopolitical factors can influence the international flow of food products, impacting both producers and consumers.

Price Volatility:

- Food prices can be volatile due to factors such as weather conditions, crop diseases, and geopolitical events. These fluctuations can affect inflation rates and consumer purchasing power.
- Governments often intervene to stabilize food prices through policies such as subsidies, price controls, and strategic reserves.

Technology and Innovation:

- Advances in agricultural technology, such as genetically modified organisms (GMOs), precision farming, and automation, can impact productivity and efficiency.
- Investments in research and development in the agricultural sector contribute to economic growth and competitiveness.

Environmental Impact:

The environmental sustainability of food production practices is gaining importance. Sustainable agriculture practices can have economic benefits by ensuring long-term productivity and minimizing environmental degradation.

Food Security:

Adequate food production is essential for ensuring food security. Governments often implement policies to address issues related to food access, availability, and affordability to safeguard the well-being of their populations.

Supply Chain Dynamics:

The economics of food production are closely tied to the efficiency of supply chains. Transportation, storage, and distribution systems impact the overall cost and accessibility of food products.

Government Policies and Subsidies:

Governments play a significant role in shaping the economics of food production through policies, subsidies, and regulations. These measures can influence the choices of farmers, the prices of agricultural products, and the overall stability of the food supply.

Understanding the complex interactions between food production and economics is essential for policymakers, agricultural professionals, and stakeholders to develop strategies that promote sustainable, efficient, and equitable food systems.

History of Food Safety,

The history of food safety is marked by a series of events and developments aimed at ensuring the quality and safety of the food we consume. The following are the key milestones in the history of food safety:

Ancient Times:

- Early civilizations recognized the importance of food safety through basic practices such as cooking and fermentation.
- Ancient texts from civilizations like the Greeks and Romans documented food preservation methods.

Middle Ages:

- During this period, various preservation techniques, such as salting, smoking, and drying, became more widespread.
- The emergence of food markets and trade increased the need for food safety regulations.

Renaissance and Enlightenment (14th-18th centuries):

- Scientific advancements led to a better understanding of microbiology and the role of microorganisms in food spoilage.
- Antonie van Leeuwenhoek's microscope observations laid the groundwork for the understanding of bacteria.

19th Century:

- The Industrial Revolution brought about changes in food processing and distribution, leading to increased concerns about food safety.
- Sir Edwin Chadwick's report on sanitation and public health in the UK highlighted the need for better hygiene practices in food handling.

Late 19th to Early 20th Century:

- Upton Sinclair's novel "The Jungle" (1906) exposed unsanitary practices in the meatpacking industry in the United States, leading to the passage of the Pure Food and Drug Act and the Meat Inspection Act in 1906.
- The establishment of food safety agencies and regulatory bodies, such as the Food and Drug Administration (FDA) in the United States, marked a significant step in ensuring food safety.

Mid-20th Century:

- Advances in food science and technology, including the development of food additives and preservatives, raised new questions about their safety.
- The Codex Alimentarius Commission, established by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) in 1963, began setting international food standards.

Late 20th Century:

- Increased globalization of the food supply chain necessitated the development of international food safety standards and regulations.
- The Hazard Analysis and Critical Control Points (HACCP) system, developed by NASA and the Pillsbury Company in the 1960s, gained widespread adoption in the food industry as a preventive approach to food safety.

21st Century:

- Advances in technology, such as DNA testing and rapid detection methods, have enhanced the ability to identify and trace foodborne pathogens.
- The Food Safety Modernization Act (FSMA) in the United States, signed into law in 2011, shifted the focus from responding to foodborne illness outbreaks to preventing them.

Ongoing Challenges:

- Globalization, climate change, and emerging pathogens continue to pose challenges to food safety.
- International collaboration and the adoption of new technologies play a crucial role in addressing these challenges and ensuring a safer food supply.

The history of food safety is an ongoing narrative shaped by scientific discoveries, technological advancements, and regulatory measures aimed at protecting public health.

Foodborne illness has threatened human health since the dawn of time. In fact, many food preparation methods we still use today, such as cooking, canning, smoking, and fermentation, can be understood as primitive food safety measures, developed as a means of keeping people from getting sick.

In 1905, American author Upton Sinclair published his novel The Jungle, which featured horrific depictions of Chicago’s meatpacking industry. The ensuing public outrage led the U.S. government to pass the Meat Inspection Act the following year, establishing the first sanitary standards for slaughtering and butchering. This law marked the first time that food processing facilities were subject to regular audits and inspections by governmental authorities and some of the very first laws for food safety in manufacturing.

Across Europe and North America, the industrial revolution ushered in the establishment of many regulatory bodies and foundational laws concerning food safety and inspection. As food production became increasingly mechanized and profit incentives climbed, laws were passed to prevent the intentional sale of food products that were misbranded, contaminated, or otherwise tampered with. It was during this era that ingredients and additives became subject to regulation.

In the decades following World War II, electric refrigerators entered middle class homes across Europe and North America, changing the way that everyday people purchased and stored food. The era of home refrigeration sparked the rapid expansion of industrial food production, as well as a growing need for stricter food regulations. It was in this changing food landscape that Mars Incorporated became the first major food manufacturer to install metal detectors in their facilities in 1947.

The shift from reactive to proactive food safety principles began when HACCP was born in 1959. Recognizing that testing finished products was not an effective means of ensuring food quality and safety, scientists at NASA collaborated with the Pillsbury Company to create a risk-based system that identified "critical failure areas" in production that posed health risks. With Pillsbury leading the way, this system of hazard analysis and control was adopted by a number of leading food manufacturers in the United States.

By the mid-1980s, scientists around the world agreed that the proactive nature of HACCP provided a more effective means of controlling for food safety hazards than traditional inspection methods. The following decades saw the establishment of international regulatory bodies and third-party audit firms designed to implement and enforce preventative compliance in an increasingly globalized food industry. It is upon this groundwork that modern food safety regulations and practices are built.

History of food safety Act

The **Food Safety and Standards Authority of India** (**FSSAI**) is a statutory body under the administration of the Ministry of Health and Family Welfare, Government of India. It regulates the manufacture, storage, distribution, sale, and import of food articles, while also establishing standards to ensure food safety. The FSSAI was established by the Food Safety and Standards Act, 2006, which consolidated all former acts and orders related to food safety that were previously handled by various ministries and departments.

The FSSAI has its headquarters at New Delhi. There are 22 referral laboratories notified by FSSAI, 72 State laboratories located throughout India and 112 laboratories are NABL accredited private laboratories notified by FSSAI.

The FSSAI is headed by a non-executive chairperson, appointed by the central government, either holding or has held the position of not below the rank of Secretary to the Government of India. The FSSAI provisions are enforced by Food Safety Officers. Food Safety Officers are responsible for enforcing and executing the provisions of the Food Safety and Standards Act, 2006 within their designated areas. The Commissioner of Food Safety and Designated Officer have the authority to exercise the same powers as Food Safety Officers.

Food Safety Officers possess the right to enter and inspect any place where food articles are manufactured, stored, or exhibited for commercial purposes. They are authorized to collect

samples for analysis by a Food Analyst. The authority of a Food Safety Officer to enter and inspect premises is equal to that of a police officer equipped with a search warrant under the Code of Criminal Procedure (CrPC). They can issue registrations to food business operators

Functions of FSSAI

- Creating Guidelines and Standards – FSSAI establishes rules and norms that must be followed by all food production enterprises, taking hygiene and food safety into account.
- Awarding License — The proprietor must obtain a certificate and license from the FSSAI before starting any food-related business.
- The organization tests the standard and quality of food manufactured by all enterprises registered under the FSSAI.
- Conducting Audits — Food-producing and manufacturing enterprises are inspected to ensure that their standards meet the norms.
- Literacy about food safety – The FSSAI is r
- Literacy about food safety – The FSSAI is responsible for raising public awareness and informing citizens about the necessity of eating safe and hygienic food.
- Retain Records and Information – The FSSAI also keeps correct records and data for all registered organizations. Any breach of the FSSAI's rules might result in the license being revoked.
- Keeping the Government Informed — Any threat to food safety must be reported to the appropriate government authorities for further action. Assist them in developing food safety policies.

initiatives by FSSAI to ensure Food safety

FSSAI has also taken a number of critical initiatives to ensure food safety and standards. A couple of these significant undertakings are listed below:

- Eat Right India – The goal is to give quality meals to everyone, not only to supply food to everyone. FSSAI hopes to make good quality food available to all citizens of the country through this effort.
- Clean Street Food entails educating and training street food vendors by the FSSAI Act 2006. This will also assist street food vendors in their economic development.
- Diet4Life is another FSSAI project aimed at raising awareness about metabolic illnesses.
- Save Food, Share Food, Share Joy – encouraging people to donate food rather than waste it. FSSAI hopes to connect food-collecting agencies with food-producing corporations and then distribute the food to needy people.
- World Food Safety Day– FSSAI commemorated the first-ever World Food Safety Day on June 7, 2019, by recognizing the contributions of states, food industries, and citizens to food safety.
- Heart Attack Rewind– On November 30, 2018, the Food Safety and Standards Authority of India (FSSAI) launched the "Heart Attack Rewind" national media campaign to eliminate industrially manufactured trans-fat from the food supply. It will contribute to the FSSAI's global goal of eliminating trans-fat in India by 2022.

- FSSAI-CHIFSS is a project between the FSSAI and the CII-HUL Initiative on Food Safety Sciences to foster food safety partnerships between industry, science, and academics.

FSSAI guidelines to limit trans-fat in food items

- India joins a group of roughly 40 countries around the world that have already implemented best-practice policies to remove trans fats and would be one of the first Asian countries to do so after Thailand.
- Industrial trans fatty acids are defined as: "All geometrical isomers of mono-unsaturated and polyunsaturated fatty acids with non-conjugated carbon-carbon double bonds in the trans configuration, interrupted by at least one methylene group.
- By January 2021, industrial TFA (trans fatty acids) in all fats and oils must be no more than 3%, and no more than 2% by January 2022.
- According to the Food Safety and Standards (Prohibition and Restrictions on Sales) Second Amendment Regulations, 2021. On and after January 1, 2022, all food products that contain edible oils and fats as an ingredient must not contain industrial trans fatty acids in excess of 2% by mass of the total oils/fats present in the product
- Trans-fatty acids are prohibited in dairy, meat, fish, and their products.

State Food Safety Index (SFSI)

The State Food Safety Index (SFSI), was developed in 2018 in collaboration with the FSSAI. The SFSI was created to motivate the States and Union Territories to improve their performance and work towards establishing an appropriate food safety ecosystem.

Internationally recognized food safety organizations and certification programs include:

IFS Food 6.1 – The *IFS Food Standard* is part of the *Global Food Safety Initiative* and is an international standard for performing audits of food manufacturing processes. Their compliance audits concern both the factory floor and administrative duties, with regulations on topics ranging from the installation of food defense and inspection equipment to thorough bookkeeping.

BRCGS – The *British Retail Consortium Global Standards* (formerly BRC) are a set of international consumer protection certifications that provide safety criteria for global food retailers, food manufacturers, packaging manufacturers, and food service organizations. Their certification for food manufacturers includes an assessment of the equipment used to detect and remove physical contaminants.

SQF – The *Safe Quality Food Institute* provides detailed safety programs tailored to the specific concerns of different food industry players. The various SQF codes are segmented to address the unique conditions of each stage of the food production life cycle, from agriculture to packaging, from manufacturing to retail. Each SQF program is internationally recognized.

Each of these private food safety organizations have built their certification programs around ISO 22000, an international norm for food safety management systems:

ISO 22000 – The *International Organization for Standardization* details a proactive management plan for food safety relevant for any organization along the food supply chain. ISO 22000 includes an interactive communication strategy between upstream and downstream industry players and a comprehensive system for management. Furthermore, the norm encompasses a model for how to implement a customized HACCP concept depending on the industry, product, and facilities. For instance, should a risk of metal contamination be identified, ISO 22000 may recommend the installation of a metal detector with a rejection mechanism to manage the hazard.

Food Safety Regulation In India

At present in India, the Centre and State Governments are responsible for food safety regulations and the specialised organisations have obligation for effective implementation of these regulations.

The following laws and regulations are responsible for food safety

(a) Food Safety and Standards Act, 2006;

(b) Fruit Products Order, 1955;

(c) Meat Food Products Order, 1973;

(d) Edible Oils Packaging (Regulation) Order, 1998;

(e) Solvent Extracted Oil, De-Oiled Meal and Edible Flour (Control) Order, 1967;

(f) Milk and Milk Products Order, 1992; and

(g) Vegetable Oil Products (Regulation) Order, 1998.

At the central level Ministry of Agriculture, Ministry of Food Processing Industry, Ministry of Health and Family Welfare, Ministry of Commerce and Food Safety Departments of the respective State Governments are responsible for implementation of these legislations.

The function of these governmental agencies include:

(a) review of existing standards;

(b) finalisation of standards;

(c) identification of area where there is requirement of applying new standards; and

(d) formation of standards relating to chemical content, contaminant levels and additive levels in food.

Till 2006, the Prevention of Food Adulteration Act, 1954 was the basic food safety legislation responsible for preventing food adulteration. Under this Act, the Central Committee for Food Standards (CCFS) was responsible for formulation of commodity and product standards as well as for determining limits for food contaminants.

The Central Food Laboratory (CFL) was responsible for analysing food samples and approval of standardising methods of analysis.

The Prevention of Food Adulteration Act, 1954 was also implemented in states through inspectors who operated at the market level and also during transportation and distribution of food items.

They had authority to make inspections and collect samples in accordance with prescribed regulations and submit them for analysis. The cases were filed before the magistrate and the penalty for violating the provisions of the Act varied from a fine of Rs 5,000 to a maximum of lifetime imprisonment.

The Food Safety and Standards Act, 2006 was enacted as presence of multiple regulatory agencies was hampering effective implementation of regulations governing food safety. The Food Safety and Standards Act, 2006 consolidated all existing laws governing food safety. The aim of this legislation is to provide a single reference point for all kinds of food safety standards in India.

The Food Safety and Standards Authority of India (FSSAI) established under this Act, is responsible to set standards regulating manufacturing, storage, distribution, sale and import of food products in order to ensure safe food for human consumption.

In 2015, the FSSAI issued an advisory that the Blue Bell Creameries ice cream is injurious to health as it contains bacterium Listeriamonocytogenes which weakness the immune system. Similarly, it recommended that the use of potassium bromate should be discouraged in bakeries as it causes cancer.

Recently, it has issued an advisory that packing warm food in newspaper exposes the human body to various health problems as printing ink contains cancer causing agents.

The Act has defined the word ‘food’ in a wider sense as any substance whether processed, partially processed or unprocessed which is intended for human consumption and includes primary food as well.

The Act has made it mandatory to have a licence for carrying any type of food business and has also insisted for labelling requirements for packed food items where manufactures name, manufacturing date, expiry date and nature of product is to be specified.

The Food Safety and Standards Act, 2006 has been an important step for streamlining food safety regulations.

The Export Inspection Council (EIC) established as the official pre-shipment and certification body under Export Quality Control and Inspection Act, 1963 is responsible for the pre-shipment inspection and certification of consignments which are meant for export.

The EIC provides Food Safety Management Systems (FSMS) based certification on the basis of international standards on Hazard Analysis Critical Control Point (HACCP) and Good Management Practice (GMP) for ensuring quality in food processing.

The Food Safety Management System certification is mandatory for marine products, egg based products and dairy products.

The Marine Products Exports Development Authority (MPEDA) was established to promote the implementation of HACCP system in seafood processing plants. It has encouraged seafood exports by focusing primarily on five areas namely fisheries, aquaculture, processing infrastructure and value addition, market promotion and quality control.

The present framework of food safety regulation is based on scientific and technically improved testing and certification procedures and is supported by the relevant standardising

agencies for formulation and imposition of standards. The challenge of implementation of these regulations still persists, mostly with respect to un-organised sector which can further be acknowledged by improving execution of food safety laws and by sensitising general public regarding issues involving food safety.

The Role of Food Preservation in Food Safety

Food preservation plays a crucial role in ensuring food safety by preventing the growth of microorganisms, slowing down chemical reactions, and inhibiting the activity of enzymes that can lead to spoilage. The primary goal of food preservation is to extend the shelf life of food products while maintaining their nutritional value, flavor, and quality.

Food preservatives play a vital role in preventing deterioration of food, protecting against spoilage from mold, yeast, life-threatening botulism and other organisms that can cause food poisoning. By extension, preservatives reduce food cost, improve convenience, lengthen shelf life and reduce food waste.

There are two modes of preservation: physical and chemical. Physical preservation refers to processes such as refrigeration or drying. Chemical preservation is adding ingredients to a food for the purpose of preventing potential damage from oxidation, rancidity, microbial growth or other undesirable changes — and is considered a "direct additive."

The U.S. Food and Drug Administration classifies both natural preservatives (for example, from lemon juice, salt and sugar) and artificial preservatives as "chemical preservatives." While many common preservatives occur naturally, manufacturers often use synthetic versions of these chemicals. Artificial preservatives can be divided into three major groups:

The following key aspects provides how food preservation contributes to food safety:

Microbial Control:

Pathogen Inhibition: Preservation methods such as canning, pasteurization, and irradiation help eliminate or reduce harmful bacteria, viruses, and parasites that can cause foodborne illnesses.

Spoilage Prevention: By inhibiting the growth of spoilage microorganisms like mold and yeast, food preservation methods help prevent the deterioration of food quality.

Enzyme Inactivation:

Enzymatic Browning: Some preservation techniques, like blanching and dehydration, help inactivating enzymes responsible for browning reactions in fruits and vegetables, preserving their color and appearance.

Chemical Reactions:

Oxidation Control: Preservation methods, such as vacuum packaging and the use of antioxidants, help control oxidative reactions that can lead to the development of off-flavors and deterioration of nutritional quality.

Antioxidants are preservatives help to prevent the oxidation of fats and oils, which can lead to rancidity and spoilage. Some common antioxidants include Vitamin C (ascorbic acid), Vitamin E (alphatocopherol), and BHA (butylated hydroxyanisole). Acidulants are preservatives help to lower the pH of food, making it more acidic and less hospitable to bacteria and other microorganisms. Common acidulates include citric acid, lactic acid, and acetic acid

Chelation agents are preservatives help to prevent the oxidation of food by binding to metal ions. They are often used in combination with antioxidants. Some common chelation agents include EDTA (ethylenediaminetetraacetic acid) and citric acid. Food preservation is a crucial aspect of maintaining a healthy and safe food supply.

Water Activity Control:

Drying: Removing water from food through methods like drying or dehydration inhibits the growth of spoilage microorganisms since many bacteria and fungi require water to thrive.

Temperature Control:

Refrigeration and Freezing: Keeping food at low temperatures slows down the growth of bacteria and prevents the activity of enzymes, reducing the risk of spoilage and microbial contamination.

Packaging:

Barrier Properties: Proper packaging, including vacuum sealing and gas flushing, creates a barrier against external contaminants, such as air and microorganisms, reducing the risk of spoilage and ensuring food safety.

Fermentation:

Probiotics: Fermentation not only preserves food but also promotes the growth of beneficial microorganisms, such as probiotics, which can contribute to gut health and enhance overall food safety.

Preservation of Nutrients:

Freeze-Drying: This method preserves the nutritional content of food by removing moisture at low temperatures, minimizing the loss of heat-sensitive vitamins and nutrients.

Economic Benefits:

Reducing Food Waste: Food preservation helps extend the shelf life of perishable goods, reducing the amount of food wasted and contributing to sustainable practices.

Regulations and Guidelines:

The FDA has jurisdiction over all preservatives, with the Food Safety and Inspection Service sharing responsibility for the safety of food additives used in meat, poultry and egg products. The FDA mandates that preservatives not be used in such a way as to conceal damage or inferiority, make the food appear better than it is or adversely affect the nutritive value of the food. Food additives approved for use as preservatives are listed in the U.S. Code of Federal Regulations.

Safety

According to the regulatory authorities, preservatives are generally recognized as safe, or GRAS, in the quantities in which they are allowed in individual food products. “Safe” for food additives is defined to mean “a reasonable certainty in the minds of competent scientists that the substance is not harmful under the intended conditions of use.” Still, there are some preservatives of concern.

Sodium nitrite/nitrate used in processed meats is an example of compounds that may increase the potential of these foods to cause cancer. Studies have linked eating large amounts of processed meats with an increased risk of colorectal cancer.

Sodium benzoate and sulfites appear to be safe for most people, but may cause adverse reactions in others. A 2007 study published in The Lancet suggests sodium benzoate and artificial food colorings may exacerbate hyperactivity in young children.

Although butylated hydroxyanisole, or BHA, is listed by the National Toxicology Program as “reasonably anticipated to be a human carcinogen,” the FDA considers it a GRAS substance in minute quantities. Meanwhile, butylated hydroxytoulene, or BHT, has been banned in some countries but has not been shown conclusively to be carcinogenic.

In summary, food preservation techniques are essential for maintaining the safety and quality of food products by controlling microbial growth, inhibiting enzymatic reactions, and preventing chemical deterioration. These methods contribute to the overall goal of providing consumers with safe, nutritious, and flavorful food options.

There are different ways to preserve food. Some are ancient methods that have been practiced for generations, such as **curing, smoking, pickling, salting, fermenting, canning, and preserving** fruit in the form of jam. Others include the use of modern techniques and technology, including **drying, vacuum packing, pasteurization, and freezing and refrigeration**. Preservation guards against foodborne illnesses, and also protects the flavor, color, moisture content, or nutritive value of food.

Methods of Food Preservation

Food preservation methods can be classified as follows

I. Physical Methods

A. Preservation by low temperatures

1. Refrigeration

2. Freezing

B. Preservation by high temperature

1. Pasteurization

2. Canning

C. Preservation by drying

1. Sun drying

2**. Drying by mechanical driers**

- Spray drying
- Foam mat drying
- Drying by osmosis
- Freeze drying

D. Preservation by irradiation

II. Chemical Methods

A. High concentration of salt

B. High concentration of sugar

C. Using chemical preservatives

III. Fermentation

Preservation OF food

1. Physical Methods

A. Preservation by Low Temperatures

1. Refrigeration: The temperature maintained in the refrigerator is 0 to 5°C. Enzymatic and microbial changes in foods are slowed down considerably. Perishable foods like eggs, dairy products, meat, sea foods, fruits and vegetables are stored in refrigerators. Food can be stored safely for few days or a week.

2. Freezing: The temperature of freezer is –18 to –40°C. Microbial growth is prevented completely and the action of food enzymes greatly reduced. Frozen foods have better quality and needs uninterrupted supply of electricity while storing. Foods like poultry, meat, fish, peas, vegetables, juice concentrates can be preserved for several months by this method. In vegetables, enzyme action may still produce undesirable effects on flavour and texture during freezing. Various methods of freezing include slow freezing, quick freezing, cryogenic freezing and dehydro freezing.

Quick freezing is an ideal method of preserving nearly all baked products. Bread frozen at –22oC or below retains its freshness for many months. Cakes, cookies, short cakes, waffles and pancakes are also frozen and marketed frozen.

Many food products can have their shelf-life extended by storing them at 4°C or below. Fresh fruits and vegetables, eggs, dairy products, and meats are all commonly refrigerated foods. However, some items, such as tropical fruits (bananas, for example), are destroyed by low temperatures. Freezing is an excellent way to preserve the nutritional value of foods. It's done at a temperature of –18°C to –4°C. The majority of juices are kept by freezing.

B. Preservation by High Temperature

Food commodities in which pasteurization is employed include milk, beer, wines and fruit juices.

1. Pasteurization:

It is defined as heat treatment of food material at 72°C for 15 seconds, 63°C for 30 minutes, or 90°C for 0.5 seconds, followed by quick cooling to 7°C. High-temperature-short-time (HTST) treatments are favoured over low-temperature-long-time (LTLT) treatments because they cause less damage to the nutrient composition and sensory properties of meals.

There are three methods of pasteurization.

a. Bottle or Holding Pasteurization: This method is commonly used for the preservation of fruit juices. The extracted juice is strained and filled in bottles. The bottles are then sealed air tight and pasteurized.

b. Over Flow Method: Juice is heated to a temperature about 2.5oC higher than the pasteurization temperature and filled in hot sterilized bottles. The sealed bottles are sterilized at a temperature 2.5oC lower than filling sealing temperature and then cooled.

c. Flash Pasteurization: The juice is heated rapidly to a temperature of about 5.5oC higher than the pasteurization temperature and kept at this temperature for about a minute. This method has been developed specially for canning of natural orange juice, grape and apple juice. It has the advantages of minimizing the flavor loss and preserving the vitamins.

2. Canning: Canning is the process in which the foods are heated in hermetically sealed (airtight) jars or cans to a temperature that destroys microorganisms and inactivates enzymes that can cause food spoilage.

The general steps to be adopted for canning foods are cleaning, blanching, filling, exhausting, sealing, sterilizing, cooling and labeling.

i. Cleaning: It is the first step in canning. Thorough cleaning of the product to be canned helps to remove most of the spoilage organisms.

ii. Blanching: This process serves as an additional hot water wash. It inactivates the food enzymes and fixes the natural colour of the product. It also softens the fibrous plant tissues and facilitates removal of skin. In this process the raw food material is immersed in hot water or exposed to live steam for 2–5 minutes and immediately dipped into cold water to prevent further exposure to heat.

iii. Filling: Either manually or by using machinery the contents can be filled in the cans. A headspace of 6– 9mm depth above the level of food in the can must be left.

iv. Exhausting: Gases are expelled by passing the open can containing the food through an exhaust box in which hot water or steam is used. It expands the food and expels air and other gases from contents and also from the head space area of the can.

v. Sealing: The exhausted containers are immediately sealed to avoid re-contamination.

vi. Sterilization: To bring about complete sterilization, thermal process is carried out. This ensures the destruction of spoilage microorganisms. This is usually done by the application of steam under pressure.

vii. Cooling: The containers are cooled rapidly to check the action of heat and prevent unnecessary softening of the food or change in the colour of the contents. It can be done by means of air or water.

viii. Labelling: The containers are labelled with nutritional characteristics of the food inside.

C. Preservation by Drying

Microorganisms need moisture to grow. When exposed to sunlight or subjected to dehydration, the moisture in the food is removed and the concentration of water is brought below a certain level. This prevents the growth of microorganisms and thereby spoilage of food. Food preservation by drying is one of the oldest meth-ods practiced from ancient times. This method consists of exposing food to sun-light and air until the product is dry. It is a very useful and economical process.

Both the terms ‘drying’ and ‘dehydration’ mean the removal of water. Drying is used to remove moisture by the application of unconventional energy sources like sun and wind. Dehydration means the process of removal of moisture by the application of artificial heat under controlled conditions of temperature, humidity and air flow.

Treatment of Foods Before Drying

a. Selection and sorting for size, maturity and wholesomeness

b. Washing, especially fruits and vegetables

c. Peeling of fruits and vegetables by hand, machine or knife

d. Subdivision into halves, slices, shreds or cubes

e. Blanching or scalding of vegetables and some fruits like tomatoes and peaches

f. Sulphuring of light coloured fruits and vegetables by exposure to sul-phur-di-oxide gas.

i. Sun Drying: It is limited to regions with hot climates and dry atmosphere and to certain fruits such as raisins, prunes, figs, apricots, pears and peaches. It is a slow process. Many Indian foods are preserved by sun drying. Papads, vadams and vathals are made using this principle.

Vegetables like sundaikai, cluster beans, bitter gourd and green chillies are preserved by this method. Fish and meat are also sun dried. The common dried fish or karuvadu (local name) is a good example for sun drying.

ii. Drying by Mechanical Driers: Artificial drying involves the passage of hot air with controlled relative humidity over the food to be dried or the passage of the food through such air. Fruits, vegetables, nuts, fish and meat can be successfully preserved by this method. In the dehydration process, artificial drying methods like spray drying, vacuum drying, drum drying and freeze drying are used for drying foods.

Although it is expensive when compared to natural sun-drying process, it is very hygienic, rapid and the products obtained are uniform in colour because the temperature and relative humidity can be maintained.

i. Spray drying: Milk and eggs are dried to a powder in spray driers in which the liquid is atomized and sprayed into hot air steam or almost instant drying.

ii. Foam mat drying: Foam mat drying may be used commercially to preserve orange and tomato juice. In this pro-cess a small amount of edible foam stabilizer is used. The foam is spread in a thin layer and dried in a steam of hot air. The product gets separated easily into small particles on cooling.

iii. Drying by osmosis: Drying by osmo-sis results when fish is heavily salted. In this case, the moisture is drawn out from all the cell tissues. The water is then bound with the solute making it unavailable to the microorganisms. In osmotic dehydration of fruits, the method involves the partial dehydration of fruits by osmosis in a concentrated sugar solution or syrup.

iv. Freeze drying: Removal of water from a frozen product by sublimation is called freeze drying. Freeze dried foods will be of superior quality with light and porous texture.

D. Preservation by Irradiation

Food irradiation also known as cold sterilization is another preservation technique. The foods are bombarded by high energy rays called gamma rays or by fast moving electrons to kill bacteria, fungi and insects and in some cases to delay fruit ripening or prevent sprouting in onions and potatoes. The goal of irradiation is to kill the microorganisms and inactivate the enzymes without altering the food.

2. Chemical Methods

A. Salt or Brine

It is an ancient preservation technique. Food is treated with salt or strong salt solution. Salt causes high osmotic pressure and shrinking of cell, dehydrates foods and microbes by drawing out moisture.

B. High Concentration of Sugar

Sugar has the ability to bind water and make it unavailable for microbial growth. It reduces the solubility of oxygen in moisture, which is essential for the growth and multiplication of microorganisms. Apples, oranges, guavas, grapes and pineapples are suitable for making jams and jellies. The fruits should be just ripe because the pectin content is high in such fruits.

C. Using chemical preservatives

The chemicals when added interfere with the cell membrane of the microorganisms, their enzyme activity or their genetic mechanisms. They also act as antioxidants. The common chemical preservatives permitted are

1. Benzoic acid (including benzoates) Sodium benzoate is a salt of benzoic acid and is used in preservation of coloured fruit juices and squashes.

2. Sulphur dioxide (including sulphites): Potassium meta-bi-sulphite is used as a source of sulphur dioxide when it is added to the juice or squash. When used in fruits with deep colours like blue grapes, jamun, watermelon it bleaches the colour and hence in such cases benzoic acid is desirable.

3. Organic acids and their salts:

Foods can be preserved by adding lactic, acetic, propionic, citric acids and their salts. Nitrates and nitrite compounds are used to preserve meat and fish prod-ucts. It gives desirable colour, flavor and discourages the growth of micro-organ-isms. It also prevents toxin formation by the microorganisms in food.

Salting and Pickling

Salting

Salt is added to enhance taste and extend shelf life in foods such as butter, cheese, vegetables, bread and meat products. Dry salting is used for meat, mango, amla and fish.

Pickling

It is also an ancient preservation technique. The preservation of fruits and vegetables using common salt, vinegar, oil and spices are referred to as pickling. The layer of oil that floats on the top of pickles prevents the entry and growth of microorganisms like moulds and yeast. Spices like turmeric, pepper, chilli powder and asafoetida retard the growth of bacteria. Vinegar provides an unfavorable acidic environment for microbial growth. The salt added absorbs water and prevents the growth of micro-organisms.

Fermentation

Fermentation is one of the age-old methods of food preservation techniques. Fermentation is a metabolic process in which substances undergo decaying in presence of microorganisms to produce desired compounds that can be utilized for improving food quality and safety. Preservation of food by the fermentation process is a great method to preserve foodstuffs even in industrial level. Fermentation not just prolong the shelf life of food but also has many added advantages like it improves the sensory properties of food and even improves the nutritional value of that food itemFermentation means the process of the reaction between microorganisms and organic compounds in natural conditions. Apart from carbohydrate, microorganisms and enzymes react on protein and fat by releasing carbon-di-oxide and other gases.

Fermented foods can be defined as the food which has been subjected to desirable physical and biological changes by the action of microbes (yeast, molds, etc) or enzymes that provides the food with significant modification of the food as a whole

Sterilization

Microbes are completely eliminated during sterilisation. Fruits and acidic vegetables, such as tomatoes, can be sterilised at 100°C for 30 minutes; however, non-acidic veggies must be sterilised at 116°C for 30 minutes.

Smoking process

Smoking is one of the oldest of food preservation methods. The smoking process allows cured meats, poultry, game and seafood to be subjected to smoke in a controlled environment. The smoke is produced by smoldering hardwood chips, vines, herbs, fruit skins, or spices. This smoke influences the flavor, aroma, texture, appearance and shelf life of foods.

Dehydration

Dehydration is the process of removing moisture from food materials in order to preserve them. The temperature of dehydration starts at 43°C and gradually rises to 60–66°C (for vegetables) and 66–71°C (for meat) (for fruits).

Curing process

Curing may be defined as the addition of salt (Sodium chloride), sugar and nitrate or nitrite to the meat, which results in conversion of the meat pigments into the characteristic cured meat pigments imparting the characteristic cured meat colour and production of characteristic meat flavour.

The process of meat curing is currently valued as a means of imparting organoleptic qualities to the cured products, though it originally was introduced as a means of preserving meat.

Due to the advent of efficient and widespread refrigeration the need for preserving meat by curing alone has reduced.

Apart from chacteristic colour and flavour, the meat packing industry is concerned with the following attributes also:

- Preservation,

- Tenderness and
- Yield.

Curing Ingredients

- Sodium chloride
- Sodium or potassium nitrate
- Sodium nitrite
- Monosodium glutamate
- Sugar
- Acetic acid
- Vinegar and
- Spices

Action of Curing Ingredients

Salt

- Salt acts by dehydration and alteration of osmotic pressure so that it inhibits bacterial growth and subsequent spoilage.
- It ionizes to yield the chlorine, which is harmful to the organisms.
- It sensitizes the cells against CO_2.
- It interferes with the proteolytic enzyme action.
- The effectiveness of sodium chloride varies directly with its concentration and storage temperature.
- An acceptable level of salts in hams has been reported to be about 3% and about 2% for bacon.

Sugar

- Sugar softens the products by counteracting the harsh and hardening effects of salt.
- It interacts with amino groups of the proteins and upon cooking, forms browning of the products, which enhances the flavour of the cured meats.
- Sugar substitutes have been used in bacon cures to prevent excessive browning during cooking.
- It acts as a preservative by dehydration.

Nitrates and Nitrites

- Nitrates and nitrites bring about the desired pink colour development – nitrosyl hemochromes.
- Both nitrates and nitrites are used where nitrates act as a reservoir for nitrites.
- Nitrate raise the oxidation-reduction potential and therefore are more favourable to aerobic than anaerobic organisms.
- They inhibit the growth of food poisoning and spoilage organisms. It has been clearly demonstrated that nitrite is effective in preventing the growth of the *Clostridium botulinum* organism.
- They retard the development of rancidity.

- Nitrate or nitrite alone or in combination of both shall not be more than 200 ppm in finished products as it is toxic.
- The European Directive 95/2/CE (1995) allows 150 ppm of nitrite (if alone) or 300 ppm when combined (nitrite plus Nitrate), and the residual values should be less than 50 ppm (if alone) or 250 ppm (if combined).
- There are more stringent limits for curing agents in bacon to reduce the formation of nitrosamines. For this reason, Nitrate is no longer permitted in any bacon (pumped and/or massaged, dry cured, or immersion cured).