**CHAPTER- 18**

**FOOD STORAGE AND PRESERVATION**

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**Introduction**

In a world where access to fresh food can be unpredictable, the practice of food storage and preservation becomes essential. This chapter delves into the crucial methods and techniques that enable us to extend the shelf life of food items, maintain their quality, and ensure their availability even during times of scarcity. It highlights the importance of understanding the types of food and their classification in the context of food storage and preservation, as different foods have varying storage requirements. From ancient times to the modern-day, humans have employed various ingenious methods to store and preserve food. Whether it's drying, salting, fermenting, canning, freezing, or refrigeration, each preservation technique has its unique history and significance. Throughout this chapter, we will explore the science behind food spoilage and the principles that govern effective preservation. Understanding the causes of food deterioration enables us to make informed decisions about the most appropriate preservation method for specific types of food. Furthermore, we will discuss the impact of food storage and preservation on food security and food waste reduction. As we face various challenges like population growth and climate change, learning how to preserve food efficiently becomes crucial in promoting responsible consumption and resilience in the face of uncertainties. Through this exploration of food storage and preservation techniques, readers will gain valuable insights into the age-old wisdom that helps us safeguard the abundance of the harvest and nourish communities in times of plenty and scarcity alike. By implementing effective preservation methods, we can ensure a steady food supply, reduce food waste, and bolster food security for the benefit of present and future generations.

* 1. **Foods**

Food is any substance that is consumed by living organisms to provide them with essential nutrients, energy, and sustenance for growth, maintenance, and overall well-being. It is typically of plant or animal origin, and humans consume a wide variety of foods to meet their nutritional needs and satisfy their hunger. Food can be in solid or liquid form and encompasses a vast range of items, including fruits, vegetables, grains, meat, dairy products, seafood, nuts, seeds, and beverages. The nutrients present in food, such as carbohydrates, proteins, fats, vitamins, and minerals, play vital roles in supporting various physiological functions and maintaining good health. Foods undergo spoilage due to microbial, chemical, or physical actions. Nutritional values, color, texture, and edibility of foods are susceptible to spoilage. Therefore, foods are required to be preserved to retain their quality for longer period of time.

**Classification of foods**

Food spoilage is a natural process; through this process, food gradually loses its color, texture, favor, nutritional qualities, and edibility. Consumption of spoiled food can lead to illness and in the extreme situation to death.

1. **Food categories based on shelf life:** Considering the self-life, food items can be classified as perishable, semi-perishable, and non-perishable
* **Perishable:** Foods that have shelf life ranging from several days to about three weeks are known as perishable. Milk and dairy products, meats, poultry, eggs, and seafood are the examples of perishable food items. If special preservation techniques are not apprehended, food items could be spoiled straight away.
* **Semi-perishable:** Different food items can be preserved for long time (about six months) under proper storage conditions. These foods are known as semi-perishable. Vegetables, fruits, cheeses, and potatoes are few examples of semi-perishable food items.
* **Non-perishable:** Natural and processed foods that have indefinite shelf life are called non-perishable food items. These foods can be stored for several years or longer. Dry beans, nuts, four, sugar, canned fruits, mayonnaise, and peanut butter are few examples of nonperishable foods.
1. **Food categories based on extent and purpose of processing**
* **Unprocessed or Minimally Processed Foods:** Unprocessed or minimally processed foods are those that undergo little to no processing before reaching the consumer. These foods are typically fresh and include fruits, vegetables, whole grains, nuts, seeds, and unprocessed meats. Since they undergo minimal processing, they are more susceptible to natural spoilage due to microbial activity, enzymatic reactions, and physical factors. Proper storage conditions, such as refrigeration or freezing, can help slow down spoilage and extend their shelf life.
* **Processed Culinary or Food Industry Ingredients:** These foods undergo some level of processing to make them suitable for cooking or inclusion in recipes. Examples include chopped vegetables, packaged flours, oils, canned beans, and frozen fruits. While they are partially processed, they may still be prone to spoilage if not stored properly. For instance, canned foods may spoil if the seal is broken, allowing bacteria to contaminate the contents.
* **Ultra-Processed Food Products:** Ultra-processed foods are heavily processed and often contain numerous additives, preservatives, and artificial ingredients. These products include ready-to-eat meals, packaged snacks, sugary drinks, and processed meats. Due to their high level of processing and extensive use of preservatives, they generally have a longer shelf life compared to unprocessed or minimally processed foods. However, they may still be subject to spoilage over time, and their nutritional quality may degrade with prolonged storage.

Regardless of the category, the quality and shelf life of food products can be affected by various factors, such as temperature, humidity, light exposure, and the presence of microorganisms. Proper food storage and preservation techniques, such as refrigeration, freezing, canning, and vacuum packaging, play crucial roles in preventing or delaying food spoilage and ensuring that consumers have access to safe and high-quality food products. Understanding the different categories of food and their susceptibility to spoilage helps in making informed choices about storage methods and reducing food waste.

* 1. **Importance of Food Storage**

 Food storage plays a vital role in preserving the nutritional value, flavor, and safety of our food. It allows us to extend the shelf life of perishable items, reduces food waste, and ensures we have access to nourishing meals during emergencies or unforeseen circumstances. Proper food storage practices also help prevent foodborne illnesses and maintain food quality. Food storage plays a vital role in our daily lives and has significant importance for various reasons:

1. **Food Safety:** Proper food storage is crucial for ensuring the safety of our food. When perishable foods are not stored correctly, they can become contaminated with harmful bacteria, viruses, or fungi that can cause foodborne illnesses. By following appropriate storage practices, such as maintaining proper temperatures and preventing cross-contamination, we can reduce the risk of foodborne diseases and protect the health of ourselves and others.
2. **Minimizing Food Waste:** Food storage helps reduce food waste, which is a pressing global issue. Inadequate storage can lead to premature spoilage, causing food to be discarded before its intended use. By employing suitable storage methods, we can extend the shelf life of perishable items, utilize leftovers effectively, and minimize food waste in households, restaurants, and food production facilities.
3. **Cost Savings:** Proper food storage can result in significant cost savings. When food is stored correctly, it maintains its quality and remains safe for consumption for a more extended period. This reduces the need for frequent grocery shopping and minimizes the risk of buying excessive quantities that might go to waste. By maximizing the shelf life of our food through proper storage, we can reduce expenses and make the most of our food purchases.
4. **Emergency Preparedness:** In times of emergencies or natural disasters, access to fresh food may be limited. Adequate food storage practices can ensure a reliable food supply during such situations. By stocking up on non-perishable food items, canned goods, and other long-lasting provisions, we can be better prepared to sustain ourselves and our families during unforeseen circumstances.
5. **Availability of Seasonal Foods:** Proper food storage enables us to enjoy seasonal foods throughout the year. By preserving fruits, vegetables, and other seasonal produce when they are abundant, we can extend their availability and enjoy their flavors even when they are out of season. This enhances our culinary experiences and allows us to maintain a diverse and nutritious diet throughout the year.
6. **Food Security:** Food storage is a critical component of food security. It ensures that an adequate food supply is available to meet the nutritional needs of individuals and communities. By storing surplus food during times of abundance, we can bridge gaps in food availability during times of scarcity or when access to fresh food is limited. This is especially important in regions with challenging climatic conditions or areas prone to natural disasters.
	1. **Factors Affecting Food Storage**

Several factors can influence the storage life and quality of food. Understanding these factors is crucial for implementing effective food storage practices. Here are the key factors that can affect food storage:

1. **Temperature:** Temperature is one of the most critical factors affecting food storage. The growth of microorganisms, such as bacteria, yeast, and mold, accelerates at higher temperatures. Therefore, it is important to store perishable foods, including meats, dairy products, and fresh produce, at temperatures below 40°F (4°C) in a refrigerator or freezer. On the other hand, certain non-perishable items, like canned goods or dry pantry staples, can be stored at room temperature without significant quality degradation.
2. **Humidity:** Humidity refers to the amount of moisture present in the air. High humidity levels can contribute to the growth of mold and spoilage microorganisms, while low humidity can lead to food dehydration and quality deterioration. It is essential to store food in a controlled environment with appropriate humidity levels. Perishable items like fruits and vegetables often require higher humidity, while dry goods should be stored in low humidity conditions to prevent moisture absorption and spoilage.
3. **Light:** Light exposure can cause various negative effects on stored food. Ultraviolet (UV) light can degrade the quality of certain food components, leading to nutrient loss, flavor changes, and color fading. It is best to store food in opaque or dark containers to protect them from direct light. This is particularly important for light-sensitive items such as oils, spices, and beverages.
4. **Oxygen Exposure:** Oxygen plays a significant role in the degradation of food quality. It can promote oxidation, leading to the breakdown of nutrients, off-flavors, and rancidity. Certain microorganisms also require oxygen to thrive and spoil food. To minimize oxygen exposure, consider using airtight containers, vacuum sealing, or utilizing oxygen absorbers in packaging, especially for items prone to spoilage, such as fats, nuts, and seeds.
5. **Packaging:** The packaging material and method used for storing food can impact its shelf life and quality. Suitable packaging should protect against moisture, oxygen, light, and potential contaminants. Proper packaging can include using airtight containers, zip-lock bags, aluminum foil, or vacuum-sealed pouches, depending on the specific storage requirements of the food item.
6. **Pest Control:** Pests like rodents, insects, and pantry moths can cause significant damage to stored food. Proper pest control measures, such as sealing containers tightly, using pest-resistant materials, and maintaining cleanliness, are essential to prevent infestations and protect the integrity of stored food.
7. **Product Quality:** The initial quality of the food product itself can influence its storage life. For example, fresher and higher-quality produce will have a longer shelf life compared to those that are already damaged or bruised. It is important to consider the quality of the food at the time of purchase and use proper storage practices accordingly. By taking into account these factors and implementing appropriate storage conditions, individuals can extend the shelf life of their food, maintain its quality, and reduce the risk of foodborne illnesses and wastage.
	1. **Short-Term Food Storage**

Short-term food storage typically refers to preserving food for a few days to a few weeks. It involves storing perishable items that are meant to be consumed relatively quickly. Following these guidelines can help keep perishable foods fresh, safe, and prevent waste. Here's a recap of the key points:

* 1. **Refrigeration:** Store perishable foods in the refrigerator at the appropriate temperature range of 32°F to 40°F (0°C to 4°C). This temperature range slows down bacterial growth, keeping the food safe to eat for a longer time.
	2. **Proper Packaging:** Use airtight containers, plastic wraps, or resalable bags to package and store food items in the refrigerator. This helps maintain freshness, prevents exposure to air and moisture, and reduces the risk of cross-contamination between different foods.
	3. **FIFO (First-In, First-Out):** Practice the FIFO method, which means using older food items before newer ones. Label containers with the date of storage, so you know which items should be consumed first, ensuring that nothing goes to waste.
	4. **Proper Organization:** Arrange the food items in the refrigerator in a way that allows for proper air circulation. Avoid overcrowding and keep raw meats and other potentially hazardous foods separate from ready-to-eat items. This organization helps prevent the transfer of odors and potential contamination between different foods. By following these guidelines, you can optimize the freshness and safety of your perishable foods during short-term storage.
	5. **Long-Term Food Storage**

Long-term food storage is designed to extend the shelf life of food for several months or even years. This is particularly useful for emergency preparedness or situations where access to fresh food is limited.

Consider the following guidelines for long-term food storage:

 **a. Dry Storage:** Dry storage is a food storage method suitable for various items such as grains, legumes, pasta, dried fruits, and spices. The objective of dry storage is to maintain the quality and freshness of these foods by protecting them from moisture and pests.

Here are the key steps to implement dry storage effectively:

* **Suitable Items:** Dry storage is ideal for non-perishable food items that have low moisture content, such as rice, beans, lentils, quinoa, oats, dried fruits, nuts, and spices.
* **Cool, Dry Place:** Store the items in a cool, dry location where the temperature remains relatively stable and not subject to extreme fluctuations. A pantry or cupboard in a climate-controlled area of the house is a common choice.
* **Avoid Direct Sunlight:** Exposure to direct sunlight can lead to temperature variations and degrade the quality of the stored food. Keep the storage area away from windows or any other sources of direct sunlight.
* **Minimize Humidity:** High humidity can cause mold growth and spoilage in dry foods. Choose a storage area with low humidity levels, such as a dry basement or a dedicated dry storage room.
* **Airtight Containers:** Use airtight containers made of glass, plastic, or food-grade metal to store the dry foods. Properly sealed containers prevent moisture, air, and pests from contaminating the contents.
* **Food-Grade Buckets:** For larger quantities of dry food, consider using food-grade buckets with tightly sealed lids. These buckets are commonly used for bulk storage of grains and other dry goods.
* **Labeling:** Clearly label the containers or buckets with the contents and the date of storage. This practice helps in identifying the items and monitoring their shelf life.

By following these guidelines for dry storage, you can effectively preserve the quality and freshness of your non-perishable food items, ensuring they remain safe and ready to use for an extended period. Regularly inspect and rotate the stored items to use older ones first, helping to reduce food waste and maintain a well-organized dry storage system.

**b. Canning:** Canning is a food preservation method that involves the process of packaging food items in jars or cans and subjecting them to heat to destroy microorganisms, enzymes, and other spoilage agents. The goal of canning is to create an airtight seal, preventing the re-entry of contaminants, which helps to extend the shelf life of the canned food and maintain its quality and safety over an extended period. By effectively eliminating harmful bacteria and enzymes, canning ensures that the food remains safe for consumption and retains its nutritional value even after long-term storage.

The canning process typically includes the following steps:

* **Preparation:** Start by selecting fresh, high-quality ingredients. Wash and prepare fruits, vegetables, or meats as needed.
* **Packing:** Pack the prepared food tightly into clean and sterilized glass jars or metal cans. Leave appropriate headspace to allow for expansion during processing.
* **Adding Liquid:** Depending on the type of food being canned, you may need to add liquid, such as water, brine, or syrup, to ensure proper coverage of the contents.
* **Sealing:** Place lids on top of the jars or cans and secure them with bands or caps. The lids must be new and designed for canning to ensure a proper seal.
* **Heat Processing:** The sealed jars or cans are then subjected to heat treatment, which varies in time and temperature depending on the type of food and the size of the container. The heat kills harmful microorganisms, enzymes, and bacteria, ensuring the food's safety and long shelf life.
* **Cooling and Sealing:** After heat processing, the jars or cans are allowed to cool, and a vacuum seal forms as the contents contract. This hermetic seal prevents the growth of microorganisms and further spoilage.

Properly canned food can be safely stored at room temperature, typically for up to one to two years or even longer, depending on the type of food and the quality of the canning process.

**c. Freezing:** Long-term food storage through freezing is an effective method to extend the shelf life of various foods, preserving their quality and nutritional value. Freezing works by lowering the temperature of food below freezing point, which significantly slows down microbial activity, enzyme reactions, and other processes that lead to spoilage.

Here are the key steps to ensure successful long-term food storage through freezing:

* **Suitable Foods:** Not all foods are suitable for freezing, as the texture and taste may be affected. However, many foods can be frozen successfully, including fruits, vegetables, meats, poultry, fish, dairy products, baked goods, and prepared meals.
* **Proper Packaging:** To prevent freezer burn and maintain the quality of the frozen food, it is essential to use appropriate packaging. Use airtight containers, freezer bags, or heavy-duty aluminum foil to seal the food tightly and minimize air exposure.
* **Remove Air:** When using freezer bags, try to remove as much air as possible before sealing. For containers, leave enough headspace to accommodate any expansion that may occur during freezing.
* **Labeling:** Always label the containers or bags with the date of freezing and the contents. This practice helps in identifying the items and ensures that you use the oldest items first, practicing a first-in, first-out (FIFO) approach.
* **Freezer Temperature:** Set your freezer to maintain a constant temperature of 0°F (-18°C) or below. Keeping the temperature stable is essential for ensuring the long-term quality and safety of the frozen food.
* **Pre-treatment for Fruits:** Some fruits may benefit from a quick blanching or sugar syrup treatment before freezing. This helps preserve their texture and color.
* **Freeze in Portions:** Consider freezing foods in portions that match your intended usage. This way, you can thaw only what you need, reducing food waste.
* **Thawing:** Plan ahead when you need to use the frozen food. Thawing in the refrigerator is the safest method, but you can also use cold water thawing or the microwave for faster thawing.
* **Refreezing:** Avoid refreezing foods once they have been thawed, as this can lead to a loss of quality and safety. Instead, divide larger quantities into smaller portions before freezing.

By following these guidelines for freezing, you can efficiently store a variety of foods for extended periods without compromising their taste and nutritional value. Freezing is a versatile and convenient method for preserving food, making it a valuable tool in reducing food waste and ensuring a steady supply of nutritious meals throughout the year.

 **d. Dehydration:** Dehydrating foods removes moisture, making them less prone to spoilage. Use a food dehydrator or an oven at a low temperature to dry fruits, vegetables, herbs, and meats.

The process of dehydration typically includes the following steps:

* **Preparation:** Start by selecting fresh and high-quality ingredients. Wash and prepare fruits, vegetables, herbs, or meats by slicing or chopping them into uniform pieces.
* **Drying:** There are various methods to dehydrate foods, including using a food dehydrator, an oven set to a low temperature, or even the sun. A food dehydrator is a specialized appliance designed to remove moisture efficiently. Alternatively, an oven set to the lowest possible temperature can be used, but it may take longer to dehydrate the food.
* **Spacing:** Arrange the food pieces in a single layer on dehydrator trays or baking sheets. Ensure proper spacing to allow adequate airflow, which aids in the even drying of the food.
* **Dehydration Time:** The drying time varies depending on the type of food, its water content, and the drying method used. It can take several hours to several days to achieve the desired level of dehydration.
* **Testing for Dryness:** Check the food periodically during the drying process to ensure it has reached the desired dryness. Dehydrated foods should be leathery or brittle and no longer feel moist or have visible moisture.
* **Storage:** Once fully dehydrated, allow the food to cool before storing. Store the dehydrated items in airtight containers or vacuum-sealed bags to protect them from moisture and pests.

Dehydrated foods can be safely stored at room temperature for an extended period, often several months to a year or more, depending on the type of food and the level of dehydration achieved. Dehydration preserves the natural flavors and nutrients of the food, making it a popular method for creating lightweight, portable snacks for outdoor activities, such as hiking and camping. Properly dehydrated foods are versatile and can be used in various recipes and dishes. They can be rehydrated by soaking in water or adding them directly to soups, stews, or other dishes. Dehydration is an excellent way to reduce food waste and ensure a steady supply of nutritious foods throughout the year, especially for fruits and vegetables that are in abundance during certain seasons.

**e. Vacuum Sealing:** Vacuum sealing is a food preservation method that involves removing air from the packaging of food items before sealing them tightly. This process creates a vacuum environment inside the package, reducing the presence of oxygen and minimizing the risk of spoilage and freezer burn. Vacuum sealing is particularly useful for storing meats, fruits, vegetables, and other perishable items for an extended period.

The vacuum sealing process typically involves the following steps:

* **Packaging:** Place the food items to be preserved in specially designed vacuum sealing bags or containers. These bags have a one-way valve that allows air to be removed while preventing it from re-entering once sealed.
* **Removing Air:** Using a vacuum sealing machine or a handheld vacuum sealer, extract the air from the bags or containers. The machine creates a vacuum by sucking out the air from the packaging.
* **Sealing:** Once the air is removed, the vacuum sealer automatically seals the bag or container, creating an airtight and secure seal.

Vacuum sealing effectively prevents the growth of spoilage-causing microorganisms by reducing the oxygen levels within the package. This makes it an excellent option for preserving perishable foods that are vulnerable to spoilage and freezer burn, such as meats, fish, fruits, and vegetables.

**18.6 Food Preservation**

After storage of a preserved food for a certain period, one or more of its quality attributes may reach an undesirable state. In general, it is defined as the degree of fitness for use or the condition indicated by the satisfaction level of consumers. When food has deteriorated to such an extent that it is considered unsuitable for consumption, it is said to have reached the end of its shelf life. The product quality can be defined using many factors, including appearance, yield, eating characteristics, and microbial characteristics, but ultimately the final use must provide a pleasurable experience for the consumer. Quality loss can be minimized at any stage of food harvesting, processing, distribution, and storage and thus quality depends on the overall control of the processing chain.  Food preservation is the science of extending shelf life of food while maintaining its nutritional quality as much as possible and avoiding the growth of unwanted micro-organisms. Food preservation involves the practices to prevent the growth of bacteria, fungi and other micro-organisms and retarding the oxidation of fats/oils causing rancidity. The dictionary meaning of the word “preserve” is to keep safe, retain quality and prevent decomposition or undesirable fermentation.

 The principal objective of food preservation is to increase its shelf life retaining original nutritional values, color, texture, and favor. The history of ‘Food Preservation’ dates back to ancient civilization when the primitive troupe first felt the necessity for preserving food after hunting a big animal, which could not be able to eat at a time. Knowing the techniques of preserving foods was the first and most important step toward establishing civilization. Different cultures at different times and locations used almost the similar basic techniques to preserve food items. Conventional food preservation techniques like drying, freezing, chilling, pasteurization, and chemical preservation are being used comprehensively throughout the world. Scientific advancements and progresses are contributing to the evolution of existing technologies and innovation of the new ones, such as irradiation, high pressure technology, and hurdle technology. The processing of food preservation has become highly interdisciplinary since it includes stages related to growing, harvesting, processing, packaging, and distribution of foods. Therefore, an integrated approach would be useful to preserve food items during food production and processing stages.

**18.7 Need for preservation**

1. To convert preservative perishable foods to non-perishable food products.
2. To store excess foods in safe form for future use.
3. To enhance nutritive value of meals and provide variety to it.
4. To make the food available to remote areas.
5. To reduce the bulk of food for easier transport and storage.
6. To assure off season availability of perishable food and thereby food security.

**18.8 Classification of Preservatives**

There are two main classes of preservatives:

* Class I: The food preservatives derived from nature, such as salt, sugar, vinegar, spices, honey, edible oils, etc., were included in this class.
* Class II: Preservatives that are chemical, semi-synthetic, or synthetic in nature, such as benzoates, sorbates, potassium nitrites and nitrates, sulfites, glutamates, and glycerides, are included in this class. Class II preservative should be used in one food item. People consuming or using items containing more than one preservative are at risk of exposure to multiple chemicals.
1. **Classification of preservatives based on functions**
* **Antimicrobials:** Nitrites and nitrates, for example, prevent botulism (food poisoning caused by bacteria) in meat products. They can also kill or stop the growth of bacteria, yeast, and mould. Fruits, wine, and beer are protected from further deterioration by sulphur dioxide. In jams, salad dressings, cheese, and pickles, sorbates and benzoates are anti-fungal ingredients that stop the formation of mould.
* **Antioxidants:** These impede or inhibit the rancidity-causing breakdown of dietary fats and oils that takes place in the presence of air. Antioxidants come in three different varieties:

➢ Since they prevent chain reactions by interacting with free radicals, true antioxidants like butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) are frequently utilised in many food formulations as food preservatives.

➢ Ascorbic acid is one example of a reducing agent with a lower redox potential than the medicine or excipients it is protecting.

➢ The effects of other antioxidants are enhanced by antioxidant synergy, such as sodium edetate.

* **Anti-enzymatic preservatives:** These inhibit the enzymatic mechanisms that cause foods to ripen long after harvest. For example, citric acid and erythorbic acid prevent the action of the enzyme phenolase, which causes the exposed surface of sliced fruits to become brown
1. **Classification based on chemical**
* **Acids:** Boric acids, Sorbic acids, Benzoic acid.
* **Esters:** Sodium benzoate, Propylparaben, Ethylparaben, Methylparaben, Butylparaben, Sodium propionate.
* **Alcohols:** Benzyl alcohol, Chlorobutanol, Phenyl ethyl alcohol.
* **Phenols:** Chlorocresol, Phenol, o-Phenyl phenol.
* **Mercurial compounds:** Nitromersol, Thiomersal, Phenylmercuric acetate, Phenylmercuric nitrate.
* **Quaternary ammonium compounds:** Cetyl pyridinium chloride, Benzalkonium chloride.
1. **Classification based on source**
* **Natural preservatives:** These are derived from organic materials such as plants, minerals, animals, etc. Neem oil, sodium chloride, honey, sugar, spices, edible oils, etc. are a few examples.
* **Artificial preservatives:** Artificial preservatives are chemical substances added to food and other products to extend their shelf life, prevent spoilage, and maintain their quality. While some artificial preservatives are considered safe and have been approved for use by regulatory authorities, others have been associated with potential health hazards. These preservatives are manufactured by humans through chemical synthesis and are mildly active against a variety of bacteria. Examples include benzoates, sodium benzoate, sorbates, propionates, and nitrates. The Scientific Committee on Food (SCF), which is in-charge of assessing the safety of food additives, grants an E-number to an additive once it has received approval from the European Union Commission. E numbers are a universally recognized designation for compounds that have been given European Union and Swiss approval for usage. The class "Preservatives" has been given an E-number range of 200 to 299. It's important to note that the effects of artificial preservatives can vary depending on individual sensitivities and the amount consumed.

**Health hazards caused by artificial preservatives**

* **Sodium Nitrite and Nitrate:** Used primarily in processed meats like bacon, hot dogs, and deli meats, sodium nitrite and nitrate can form nitrosamines when exposed to high temperatures during cooking. Nitrosamines are known to be carcinogenic and have been linked to an increased risk of certain cancers, particularly colorectal cancer.
* **BHA (Butylated Hydroxyanisole) and BHT (Butylated Hydroxytoluene):** BHA and BHT are antioxidants used to prevent the oxidation and rancidity of fats in processed foods and cosmetics. While considered safe in small amounts, some studies have suggested that these preservatives may have potential carcinogenic properties and could lead to adverse effects on the liver and kidneys.
* **Propylparaben and Butylparaben:** These parabens are used as preservatives in various food products, cosmetics, and pharmaceuticals. They have raised concerns due to their potential endocrine-disrupting properties, which means they may interfere with hormone regulation in the body.
* **Potassium Bromate:** Used in some bread and bakery products to improve dough strength and texture, potassium bromate is considered a possible human carcinogen by the International Agency for Research on Cancer (IARC).
* **Artificial Sweeteners:** While not preservatives in the traditional sense, some artificial sweeteners like aspartame and saccharin are used to sweeten low-calorie and sugar-free products. These sweeteners have been the subject of controversy, with some studies linking them to adverse effects such as headaches, digestive issues, and potential negative impacts on metabolism.
* **MSG (Monosodium Glutamate):** Commonly used as a flavor enhancer in processed foods and restaurant dishes, MSG has been associated with "Chinese Restaurant Syndrome" or "MSG Symptom Complex," which includes symptoms like headaches, sweating, and nausea in sensitive individuals. However, research on the subject has been inconsistent, and many people can tolerate MSG without any adverse effects.
* It's essential to remember that the overall safety of artificial preservatives is a complex issue, and regulatory bodies like the U.S. Food and Drug Administration (FDA) and the European Food Safety Authority (EFSA) continuously evaluate the safety of these additives. They set acceptable daily intake levels and enforce regulations to ensure that artificial preservatives in food products do not pose significant health risks when consumed within approved limits. Nevertheless, some individuals may be more sensitive to certain preservatives, and it's always wise to be aware of ingredient labels and make informed choices about the foods you consume. If you have specific health concerns or sensitivities, consulting with a healthcare professional or a registered dietitian can provide personalized advice on food choices and preservative intake.

**18.9 Principles of food preservation**

**1.** Prevention or delay of microbial decomposition of food

* By keeping out micro-organisms (asepsis)
* By removal of micro-organisms (filtration)
* By hindering the growth or activity of micro-organisms (use of low temperature, drying, creating anaerobic conditions or using chemicals).
* By killing the micro-organisms (using heat or irradiation).

**2.**Prevention or delay of self-decomposition of food

* By destruction or inactivation of food enzymes (blanching or boiling)
* By prevention or delay of purely chemical reactions (use of antioxidants to prevent oxidation).

**3.**Prevention of damage by insects, animals, mechanical causes etc. (use of fumigants, cushioning, packaging etc.).

Keeping in viewthe various causes of deterioration of foods, various methods of food preservation have been devised on the basis of principles:-

**1. Prevention or delay of microbial decomposition**

**i) By keeping out micro-organisms (Asepsis):**Asepsis refers to keeping out the micro-organisms from the food by making use of either natural covering or providing artificial covering around the food. Natural barrier in foods include outer shell of the nuts (almond, walnut, pecan nut) skin/peel of fruit and vegetables (banana, mango, citrus, ash gourd etc.), shells on eggs, skin or fat in meat, husk of ear corn etc. Similarly packaging prevents entry of micro-organisms in the food.
For example peach or mushroom sealed in tin can, clean vessels under hygienic surroundings helps in preventing spoilage of milk during collection and processing by keeping out the micro-organisms.
 **ii) By removal of micro-organisms (Filtration):** Filtration of liquid foods through bacteria proof filters is a common method for complete removal of micro-organisms from the foods. Liquid foods are passed through the filters made of suitable material like asbestos pad, diatomaceous earth, unglazed porcelain etc and allowed to percolate through either with or without nano-filtration etc works on this principle. Centrifugation, sedimentation, trimming and washing etc can also be used but are not very effective.
 **iii) By hindering the growth and activity of micro-organisms**

**a. By using low temperature:** Microbial growth and enzyme activity is retarded in foods by storing them at low temperatures. The food commodities can be stored under cellar storage (15oC) like root crops, potato, onion refrigerator or chilling temperatures (0-5oC) like most fruits and vegetables, meat, poultry, fresh milk and milk products and under freezing temperature (-18oC to -40oC) like frozen peas, mushrooms etc.
**b. By drying of food commodity:** Removal of water from the food to a level at which micro-organisms fails to grow is an important method of preservation. Moisture can be removed by the application of heat as in sun drying and in mechanical drying or by binding the moisture with addition of sugar (as in jams, jellies) or salt (high salt in raw mangoes) and making it unavailable to the micro-organisms. Examples include osmotic dehydration, dried grapes (raisins), apricots, onion, cauliflower etc.
**c. By creating anaerobic conditions:** Anaerobic condition can be created by removal or evacuation of air/oxygen from the package, replacement of air by carbon dioxide or inert gas like nitrogen.

* Lack of oxygen prevents growth of any surviving bacteria and their spores under such conditions.
* Production of carbon dioxide during fermentation and its accumulation at the surface makes the conditions anaerobic to prevent the growth of aerobes.
* Carbonation of drinks and storing fresh food under controlled atmospheres serves the same purpose.
* Canned food in which the food is sealed after removal of air (exhausting) illustrates this principle.
* Anaerobic bacteria and their spores present however, need to be killed to prevent the food from being spoiled.
* A layer of oil on top of any food prevents growth of microbes like moulds and yeasts by preventing exposure to air.

**d. By use of chemicals:** Appropriate quantity of certain chemicals added to the food can hinder the undesirable spoilage in the food by

* Interfering with the cell membrane of the micro-organisms, their enzyme activity or their genetic mechanism
* By acting as an anti-oxidant.
* The optimum quantity of preservative as per approved regulation need to be used as higher concentrations can be a health hazard.
* Chemical preservatives are benzoic acid and its sodium salt, sorbic acid, potassium meta-bi-sulphite, calcium propionates etc.
* Common antioxidants to check off flavour (rancidity) in edible oils include butyl hydroxy anisole (BHA), butyl hydroxy toluene (BHT), tertiary butyl hydroxy quinone (TBHQ), lecithin etc.
* Addition of organic acids like citric, acetic and lactic acid in the food inhibits the growth of many organisms.

**iv) By killing the micro-organisms**
**a) Use of heat:**Coagulation of proteins and inactivation of their metabolic enzymes by application of heat leads to destruction of micro-organisms present in foods. Exposure of food to high temperature also inactivates the enzymes present in the food. Foods can be heated either at temperature below 100oC (pasteurization) at 100oC (boiling) or at temperature above 100oC (sterilization).

**i) Pasteurization (heating below 100oC):** It is a mild heat treatment given to the food to kill most pathogenic micro-organisms and is used in the food where drastic heat treatment causes undesirable changes in the food. It is usually supplemented by other methods to prolong shelf life. Pasteurization is most commonly used in treatment of milk and other dairy products either as low temperature long time (LTLT) or high temperature short time (HTST) process.

* Heat treatment of milk at 62.2oC for 30 minutes refers to LTLT process.
* Heating at 72oC for 15 seconds is termed as HTST process.
* Grape wine is pasteurized at 82-85oC for 1 minute and beer is pasteurized at 60oC.
* Pasteurization of juices depends upon their acidity and method of packing whether in bulk or in bottle or can.
* Bottled grape juice is pasteurized at 76.7oC for 30 minutes while in bulk the juice is heated to 80-85oC for few seconds by flash treatment.
* Carbonated juice is heated at 65.6oC for 30 minutes in bottles and vinegar in bulk is held at 60-65oC for 30 minutes.

**ii) Boiling (heating at 100**o**C):**Cooking of food including vegetables, meat etc by boiling with water involves a temperature around 100oC. Boiling of food at 100oC kills all the vegetative cells and spores of yeast and moulds and vegetative cells of bacteria.

* Many foods can be preserved by boiling (e.g. milk).
* Canning of acid fruit and vegetables (tomatoes, pineapple, peaches cherries etc) is carried by boiling at about 100oC.
* Various terms used for heating of food are baking (in bread), simmering (incipient or gentle boiling), roasting (in meat) frying (shallow or deep fat frying) and warming up (small increase in temperature up to 100oC).

**iii) Heating above 100**o**C:** Heating by steam under pressure is used to obtain temperature above 100oC by using steam sterilizer or retort. The temperature in the retort increases with increase in steam pressure. The temperature in retort at mean sea level is 100oC; with 5psi pressure at 109oC; with 10psi pressure at 115.5oC and with 1 kg/cm2 (100 Pa) pressure at 121.5oC.

* For canning of mushrooms and other non-acid vegetables the processing temperature of 121.1oC at 15 psi pressure are used.
* For sterilization of milk and other liquid foods like juices, ultra-high temperature (UHT) process is used.
* In UHT process, the food is heated to very high temperature (150oC) for only few seconds by use of steam injection or steam infusion followed by flash evaporation of the condensed steam and rapid cooling. The process is also used for bulk processing of many foods.

**b) Use of radiation:** Irradiation consists of exposing the food to either electromagnetic or ionizing radiations to destroy the micro-organisms present in the food. Examples of irradiation include use of ultraviolet lamps in sterilizing slicing knives in bakeries. Gamma radiation from cobalt -60 or cesium 137 source have been used for irradiation of many fruits like papaya, mango and onion, spices, fish etc. They are also used for inhibition of sprouting in onion and potatoes.

**2. Prevention or delay of self-decomposition of food**
**i) By destruction or inactivation of food enzymes (blanching or boiling):** Blanching is a mild heat treatment given to vegetables before canning, freezing or drying to prevent self-decomposition of food by destroying enzymes. Blanching is carried out by dipping the food commodity either in boiling water or by exposing than to steam for few minutes followed by immediate cooling.

**ii) By prevention or delay of purely chemical reactions (use of antioxidants to prevent oxidation):**Foods containing oils and fat turn rancid and become unfit for consumption due to oxidation. Addition of appropriate quantity of antioxidants like butyl hydroxy anisole (BHA), butyl hydroxyl toluene (BHT), tertiary butyl hydroxy quinone (TBHQ), lecithin etc prevents oxidation and preserves the food.

**iii) Prevention of damage by insects, animals, rodents and mechanical causes:** Use of fumigants in dried fruits, cereals etc. checks the damage caused by insects and rodents. Wrapping of fruits, providing cushioning trays, using light pack and good packaging material checks the damage to fresh food commodities during handling and transportation.

**Table 1: Methods of food preservation on the basis of food preservation principles.**

|  |  |
| --- | --- |
| **Physical method** | **Method** |
| a)By removal of heat (Preservation by low temperature) | Refrigeration, Freezing preservation, dehydro-freezing, carbonation |
| b. By addition of heat (preservation by high temperature | Pasteurization (LTLT, HTST), sterilization, UHT Processing, microwave. |
| c. By removal of water | Drying (open sun, solar/poly tunnel solar), Dehydration (mechanical drying), Evaporation/concentration, Freeze concentration, reverse osmosis, freeze drying, foam mat drying and puff drying |
| d. By Irradiation | UV rays and gamma radiations |
| e. By non-thermal methods | High pressure processing, pulsed electric fields |
| **Chemical methods** |  |
| a. By addition of acid (acetic or lactic) | Pickling (vegetable, olive, cucumber, fish, meat) |
| b. By addition of salt/brine | Salted mango/vegetable slices, salted and cured fish and meati. Dry saltingii. Brining |
| c. By addition of sugar along with heating | Confectionary products like jams, jellies, preserves, candies, marmalades *etc*. |
| d. By addition of chemical preservatives. | i) Use of class II preservatives like Potassium meta-bi- sulphite, sodium benzoate, sorbic acid in food products.ii) Use of permitted and harmless substances of microbial origin like tyrosine, resin, niacin as in dairy products. |
| iii. By fermentation | i. Alcoholic fermentation (wine, beer)ii. Acetic acid fermentation (vinegar)iii. Lactic acid fermentation (curd, cheese, pickling of vegetables). |
| iv. By combination method | i. Combination of one or more methods for synergistic preservation.ii. Pasteurization combined with low temperature preservation.iii. Canning: heating combined with packing in sealed container.iv. Hurdle technology like low pH, salting, addition of acid, use of sugar, humectant and heating. |

**18.10 Different food preservation methods**

* 1. **Drying:** Drying is one of the oldest ways of food preservation because it significantly lowers water activity, which delays or prevents bacterial development. Drying also helps to reduce weight.
	2. **Pickling:** By using anaerobic fermentation, pickling is a method of food preservation. Pickles are the name of the food that results. The process imparts a salty or sour flavour to the food. Vinegar, oil, alcohol, and brine are common pickling ingredients. A pH of less than 4.6, which is adequate to kill most bacteria, is another distinctive feature. Perishable foods can be preserved for months by pickling.
	3. **Canning:** If done correctly, canning is a significant, secure technique of food preservation. Canning is the process of heating food, putting it in sterilized cans or jars, and then boiling the containers to sterilize or weaken any lingering microorganisms.
	4. **Freezing:** The two methods of food preservation that are most often used nowadays are refrigeration and freezing. When food is refrigerated, the purpose is to restrict bacterial growth to a crawl such that food spoilage takes significantly longer (perhaps a week or two instead of half a day).
	5. **Chilling:** Foods are chilled at a constant temperature of between 1 and 8 °C. The cooling process lowers the products' starting temperatures and sustains their ending temperatures for an extended length of time. It is used to slow down biochemical and microbial changes as well as to increase the shelf life of both fresh and processed foods.
	6. **Jellying:** Cooking in a substance that solidifies to produce a gel can preserve food. Gelatine, agar, maize flour, and arrowroot flour are a few examples of these materials.
	7. **Vacuum packing:** Food is often vacuum-packed in an airtight bag or bottle. The lack of oxygen in the vacuum atmosphere causes microorganisms to slowly deteriorate. Food can be harmed by air, which leads to rusting, the spread of bacteria, or lost property. This approach may preserve food for weeks or even months if it is refrigerated, making it ideal for goods that travel great distances.
	8. **Water bath:** In this method, food is kept in a glass container filled with water that is firmly closed. The bottle is then put in a pot with just enough water to cover it, and the water is then turned off after 50 minutes. Before causing a rapid temperature rise that might cause the bottle to burst, leave the flask within the container until the water has totally cooled. The food may be preserved using this method for several months or even over a year.

**18.11** **Recent advanced preservation methods**

1. **Irradiation:** When a substance is exposed to a certain dose of ionizing radiation (IR), the process is called irradiation. Natural and artificial IR are both possible. High-energy ultraviolet (UV) and X-rays are common components of natural infrared (IR), while induced secondary radiation and accelerated electrons are the products of artificial infrared production. In more than 60 distinct foods across 40 different nations, IR is employed.

 The effects of IR include: (a) disinfestation of grains, fruits, and vegetables; (b) improvement of fruit and vegetable shelf life through inhibition of sprouting or by altering their rate of maturation and senescence; and (c) enhancement of food safety and shelf life through inactivation of foodborne pathogens. Kilo greys represent the IR dosage provided to foods (kGy). A grey is equal to the amount of ionizing radiation that 1 kilograms of radioactive material has been exposed to. Legislative authorities determine the boundaries of IR regulation. These restrictions may be stated as a minimum dosage, maximum dose, or acceptable dose range depending on the regulatory body. Even at large dosages, IR has no effect on the nutritional factors, such as lipids, carbs, proteins, minerals, and the majority of vitamins. When IR is administered in large doses, several micronutrients, especially the vitamins A, B1, C and E, may be lost. FDA claims that the effects of IR on food's nutritional value are comparable to those of traditional food processing methods.

1. **High-pressure food preservation:** In order to destroy germs in food, high hydrostatic pressure or ultra-high pressure processing (HPP) technology applies pressure upwards of 900 MPa. Additionally, this procedure prevents food spoiling, postpones the start of chemical and enzymatic deteriorative processes, and preserves the vital physical and physiochemical properties of food. High pressure processing has the potential to be a significant preservation technique that doesn't result in the degradation of vitamins, flavours, or colour components. The unparalleled benefits of High pressure processing technology include better freshness and flavour as well as great nutritional content. This procedure is also environmentally beneficial since it uses very little energy and produces very little waste. The high capital expense of this technology is a serious flaw. Additionally, the widespread use of High pressure processing procedures is also constrained by a lack of knowledge and scepticism regarding this technology. Le Chatelier's principle states that the combined effects of cell membrane permeabilization and breakdown result in the death or inhibition of microbial growth. While spore inactivation necessitates significantly higher pressure in conjunction with an increase in temperature to 60 to 70 °C, vegetative cells are rendered inactive at around 3000 bar pressure at ambient temperature. Since minimal influence is discernible below 40% moisture content, moisture level is crucial in this context.
2. **Pulsed electric field:** Food is subjected to a pulsed high voltage field (20–40 kV/cm) while being sandwiched between two electrodes during pulsed electric field (PEF) food preparation. The PEF treatment time is often less than one second. This process's quick residence time and low processing temperature enable extremely successful microbial inactivation. Gram-negative bacteria are considerably easier to kill with pulsed electric field processing than gram-positive bacteria. Compared to spores, vegetative cells are far more vulnerable to this process. Electroporation and disruption of cell membrane function are the causes of all cell death. Pulsed electric field technology preserves the meals' flavour, colour, and taste. Processes for non-thermal food preservation including pulsed electric field and high pressure processing are thought to be more efficient than thermal processing. The amount of pulses produced during processing and the electric field intensity (20–40 kV/cm) that are used to inactivate bacteria are the major factors in pulsed electric field. Most spoilage and harmful bacteria have been discovered to be susceptible to pulsed electric field. However, it should be emphasized that treating plant or animal cells requires a strong field and more energy, which raises the cost of processing. Additionally, the structure of solid food may be destroyed by this sort of field strength. Pulsed electric field is therefore more suited to preserve liquid foods such as fruit or vegetable juices, milk, liquid eggs, and nutritional broth.
3. **Application of Nano technology in food preservation:** One of the most important measures in ensuring food safety is food packaging. No packaging material can penetrate natural chemicals, air gases, or water vapours. In the case of packing fresh fruits and vegetables, which go through cellular respiration, completely limiting the movement and permeability of gases is not preferred. However, to avoid oxidation and decarbonation, the packaging of carbonated beverages should stop the passage of oxygen and carbon dioxide (CO2). Depending on the food matrices and packing materials employed, different amounts of CO2, oxygen, and water vapour pass through the system. In order to solve and get around these difficulties in food packaging, various nanocomposite materials, such as polymers, can be used. A nanoparticle with a diameter of less than 100 nm is a thousand times thinner than a book page that is around 100,000 nm thick or a hundred times thinner than a human hair that is about 10,000 nm thick. Recently, the capacity of food packaging to operate as a barrier against gases has improved thanks to the introduction of nanobiocomposites in food packaging. The use of environmentally friendly biodegradable polymers supplemented with nanofillers is encouraged by current trends in food packaging. The intake of these nano-compounds while consuming food, however, is a significant worry. Therefore, research into the toxic and immunogenic effects of these nanoparticles as well as their migration inside the human body is crucial. The biodegradability of these nanofilled, biodegradable polymers is a further issue. Researchers throughout the globe who are looking for ecologically and human-friendly nanomaterials take these issues seriously.
4. **Fortification of edible films with bioactive agents for the application in food preservation:** For food coating and packaging applications, biodegradable films made from food components are being researched as environmentally benign and more sustainable substitutes for plastics and other synthetic film-forming materials. A particular emphasis is placed on the development of active packaging materials using natural components, particularly those derived from plants. Proteins, polysaccharides and lipids are common dietary ingredients that are used to make film matrixes. To improve these matrices' functional qualities, active substances like antioxidants and antimicrobials can be added. To have the necessary optical, mechanical, barrier, and preservation qualities needed for commercial applications, edible active films must be properly constructed.
5. **Modified atmospheric packaging:** Modified Atmosphere Packaging, or MAP, is a natural way to extend the shelf life of food while preserving its quality and preserving the flavour, texture, and appearance of the original product. The best way to safeguard and Types of nanoparticles Matrix Application Silver Asparagus, Orange juice, Poultry meat, Fresh-cut melon, Beef meat exudates Retards the growth of aerobic psychrotrophics, yeasts and molds; antimicrobial effect against Escherichia coli and Staphylococcus aureus Zinc oxide Liquid egg albumen, Orange juice Effectively reduces Lactobacillus plantarum, Salmonella, yeast and mold counts without changes in quality parameters Titanium oxide Strawberry Reduces browning, slow-down ripening, senescence and decay Silver oxide Apple slice Retards microbial spoilage preserve food nowadays is using MAP. To preserve the original flavour, texture, and appearance of the food being packaged, MAP employs liquid nitrogen or a gas combination in modified atmospheric packaging. Nitrogen (N2), carbon dioxide (CO2), and other gases like nitrous oxide, argon, or hydrogen may also be present in MAP gas combinations. Each gas interacts with meals or liquids in a specific way that helps it maintain its original qualities. The gases can be mixed specifically for each type of product or used individually. In order to stop oxidation during packing, nitrogen, an inert gas, is typically utilised to force out ambient air. Nitrogen's poor solubility in water also contributes to its ability to maintain internal pressure and avoid package collapse, which eliminates the need for outside packaging and makes product transit and storage easier. N2 vaporises fast and expands 700 times in volume. It uses far less nitrogen and is the most efficient approach to remove oxygen while achieving container stiffness. As carbon dioxide dissolves in food's liquid and fatty phases and lowers the pH level, it aids in the inhibition of microbial activity. By piercing biological membranes, it also alters permeability.

**18.12** **Impact of food storage and preservation on food security and food waste reduction**

Food storage and preservation play a significant role in addressing crucial issues related to food security and food waste reduction. Let's explore the impact of these practices on each of these areas:

* **Food Security:** Food security refers to the availability, accessibility, and utilization of sufficient and nutritious food to meet the dietary needs of individuals within a community or country. Food storage and preservation directly contribute to food security in several ways:

**a. Ensuring Year-Round Availability:** Preservation techniques such as canning, freezing, and drying enable the storage of surplus food during times of plenty, which can be consumed during periods of scarcity or when fresh produce is not readily available.

**b. Reducing Dependence on Seasonal Crops:** By preserving foods, people can rely less on

seasonal crops, thereby mitigating the impact of crop failures due to adverse weather conditions or other factors.

 **c. Facilitating Food Distribution:** Properly preserved and stored foods can be efficiently transported and distributed to areas facing food shortages, helping to alleviate hunger in regions with limited access to fresh produce.

* **Food Waste Reduction:** Food waste is a major global challenge that not only leads to the squandering of valuable resources but also contributes to environmental degradation. Food storage and preservation have a direct impact on reducing food waste:
	+ - 1. **Prolonging Shelf Life:** Preservation techniques extend the shelf life of perishable foods, reducing the likelihood of spoilage and waste before they can be consumed. This means that food is less likely to go bad before it can reach consumers, reducing food waste at the retail and consumer levels.
			2. **Utilizing Surplus Produce:** Preservation allows individuals and food industries to manage surplus agricultural produce efficiently. Instead of letting excess food go to waste, it can be preserved and directed to markets or donations, reducing the amount of edible food that is discarded.
			3. **Value Addition to "Imperfect" Produce:** Preservation techniques can be used to process and preserve "imperfect" or visually unattractive produce that might otherwise go to waste. By turning these items into preserved products, they become suitable for consumption and reduce unnecessary discards.
			4. **Reducing Losses in the Supply Chain:** Proper food storage and preservation at various points in the supply chain, including during transportation and storage, can prevent spoilage and reduce losses, minimizing food waste before reaching the end consumer.

**Conclusion**

In conclusion, proper food storage practices are essential for maintaining the quality, safety, and longevity of our food. By considering factors like temperature, humidity, light, oxygen, and pest control, we can make informed decisions about short-term and long-term food storage. Whether you're storing food for everyday use, emergencies, or long-term storage, following the guidelines in this chapter will help you preserve the integrity of your food and ensure its availability when you need it most. These practices not only benefit individuals and communities but also contribute to global efforts towards a more resilient and sustainable food supply for future generations. The postharvest handling of foods plays a crucial role in maintaining the quality and freshness of harvested products. Balancing the use of physical and chemical treatments is essential to avoid extreme measures while ensuring food safety. Over time, food preservation techniques have advanced significantly, with innovations like pulsed electric field effect, high-pressure food preservation, and irradiation. However, concerns have also arisen regarding the use of chemical additives and preservatives due to potential health risks. Striking the right balance between innovation and safety is a constant challenge for the food processing and preservation sector. To ensure food safety and longevity, it is essential to understand the mechanisms of food degradation and stay up-to-date with the latest preservation techniques.

**Suggested Readings**

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**Applications**

**Preservatives**

**Class**

**S.No**