FOOD STORAGE AND PRESERVATION: AN ESSENTIAL KEY IN FOOD ECONOMY

Abstract

Food processing methods have long been employed to uphold food quality and ensure its preservation at the desired level, thus maximizing its nutritional advantages. The realm of food preservation encompasses the entire spectrum of activities involving the cultivation, harvesting, processing, packaging, and distribution of food. The principal objective of food preservation is to offer value-added food products, enhance dietary diversity, and address issues related to suboptimal agricultural planning. A multitude of chemical and biological interactions can lead to food spoilage. Ancient practices such as drying, chilling, freezing, and pasteurization have been harnessed and refined over time to counteract chemical and microbiological degradation of food products. Recent years have witnessed significant advancements in these preservation methods, rendering them increasingly sophisticated. Contemporary technologies including irradiation, high-pressure processing, and nanotechnology have been employed to preserve food items. This chapter delves into the mechanisms, application conditions, storage requirements, and provides an overview of various food preservation techniques. Furthermore, it explores diverse food categories and the array of factors—physical, chemical, and microbial—that contributes to food spoilage. Experts and researchers engaged in food processing, preservation, storage, and food safety will find this article instrumental in devising effective and comprehensive approaches for food preservation.

Keywords: Food preservation, food storage, food safety, food processing, spoilage

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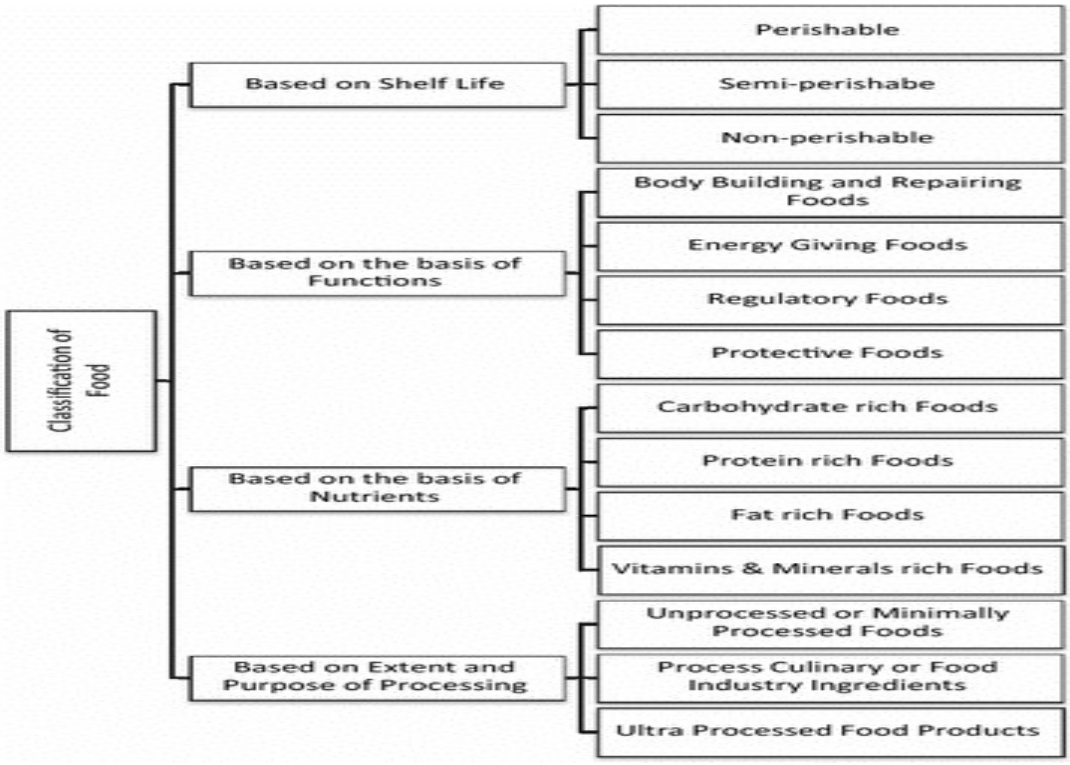
I. INTRODUCTION

Three essential methods that have been employed to increase the availability of food for human consumption are food processing, food preservation, and food packaging. Food products are processed using mechanical, chemical, and thermal techniques to improve their shelf life and palatability. Food processing converts raw materials into food products or other intermediate products, while preservation entails handling and treating food to prevent spoilage by preventing the growth and attack of microbes that cause foodborne illnesses and preventing fats from oxidizing (rancidity), which preserves the food's flavor, texture, and nutritional value (Amit et al., 2017). If food is not adequately prepared and kept, the chemicals, microorganisms, and enzymes found in the food itself might cause spoiling (Saini et al., 2021). In addition, food and its byproducts need to be moved from one location to another. Deterioration, loss or reduction of morphological characteristics, and a decline in the food's nutritional value are all possible. Thus, it is imperative to invest in food processing and preservation techniques in order to provide a longer shelf life, quality stability, preservation of morphological qualities, and preservation of the food product's flavor (Amit et al., 2017).

Over the past several years, a multitude of both traditional and modern methods have been developed, recognizing the paramount importance of food preservation in reducing post-harvest losses and the risk of foodborne illnesses. Among the most widely employed food preservation techniques are refrigeration, canning, irradiation, drying, salting, smoking, and fermentation, all of which contribute to enhancing the shelf stability of various food categories, including fruits, vegetables, meats, and fish-based products. Traditional methods, such as the conversion of fruits into jams and jellies, have demonstrated lower energy consumption and a reduced carbon footprint when compared to modern approaches (Kumar, 2019). Some traditional practices involve the boiling of fruits to eliminate microbes and reduce moisture content. By incorporating sufficient sugar, microbial regrowth can be thwarted, and sealing the products in airtight containers effectively prevents contamination (Kumar, 2019). The sugar-processing method renders jams hypertonic, making it inhospitable for microbial survival. Research efforts in food preservation encompass strategies for inhibiting the proliferation of bacteria, fungi, and other microorganisms, as well as curbing chemical reactions such as the oxidation of fats, thereby extending the shelf life of food products. Additionally, packaging research is focused on enhancing the shelf life and stability of convenient, ready-to-eat, and mildly processed food products. Presently, there is a growing emphasis on the utilization of novel biodegradable packaging materials to address environmental pollution associated with fossil-based packaging materials. This chapter offers an overview of food processing, preservation, storage, and packaging technologies employed to develop new food products characterized by extended shelf life.

II. CLASSIFICATION OF FOODS

Food can be categorised based on the nutritional quality, taste, shelf life and processing methods (Figure 1). The following flowchart represents a summary of various food groups.



(Doyle, 2009)

III. FOOD SPOILAGE

Food spoilage is the process that renders food unsuitable for human consumption (Petruzzi et al., 2017). Numerous factors contribute to food spoilage, including contamination by microorganisms, insect infestation, and enzyme degradation (Lorenzo et al., 2017). Additionally, physical alterations or instability can lead to the deterioration of food. Instances of physical deterioration encompass changes in moisture content, both gain and loss, as well as the migration of moisture between different components and the physical separation of ingredients or components (Rahman, 2009). Key factors influencing physical deterioration include moisture levels, temperature, glass transition temperature, crystal formation, and crystallization. Chemical changes, such as the oxidation of specific food constituents, are also culprits in food spoilage. The enzymes naturally present in food can break down due to certain chemical reactions catalyzed by the storage environment, resulting in food spoilage or degradation. These changes or degradation processes manifest as off-flavors, alterations in texture, and the loss of nutrients (Erkmen and Bozoglu 2016).

Different microbes commonly cause damage to perishable foods; however, most bacterial growth can be slowed or prevented by adjusting the storage temperature, lowering the pH, lowering the water activity, adding preservatives, and utilizing appropriate packaging (Tianli et al. 2014). The three main types of microorganisms that cause food to deteriorate are molds, yeasts, and bacteria. Food deterioration is typically caused by Lactobacillus, yeasts, Saccharomyces, and molds (such as Rhizopus). Foodborne infections are also brought on by fungi, such as yeasts and molds, and bacteria. Additionally, during the harvesting, storing, processing, distribution, handling, and preparation stages, microbes have the potential to

contaminate food. Table 1 lists the enzymes that lead to the deterioration of food quality (Singh and Wilfred, 2023).

Table 1: Enzymes Involved in the Degradation of Food Quality

S. No.	Enzyme	Food	Type of Spoilage
1.	Ascorbic acid oxidase	Vegetables	Vitamin C destruction
2.	Lipase	Cereals	Discoloration
		Milk	Rancidity
		Oils	Rancidity
3.	Lipoxygenase	Vegetables	Vitamin A destruction and off-flavour
4.	Pectic enzyme	Citrus juices	Pectic substances destruction
		Fruits	Softening
5.	Peroxidase	Fruits	Browning reactions
6.	Polyphenol oxidase	Fruits, vegetables	Off-flavour, browning, and vitamin loss
7.	Protease	Eggs	Shelf-life reduction of fresh and dried eggs
		Crab, lobster	Excessive tenderization
		Flour	Gluten formation reduction
8.	Thiaminase	Meats, fish	Thiamine destruction

IV. FOOD STORAGE

An integral component of food preservation is food storage. Numerous reactions cause quality degradation during storage. Improper food storage can have a negative effect on its nutritional value. For instance, foods may lose some of their vitamin C and thiamine content while stored, particularly at high temperatures (Giannakourou and Taoukis, 2021). Moreover, during storage, food loses its texture, develops bad flavors, and changes color. Thus, it is important to build an appropriate food storage system so that fresh food does not experience unfavorable modifications while maintaining its highest quality. Temperature is one of the key factors to take into account when building the food system (Singh and Wilfred, 2023). It is thought that storing food at a lower temperature will minimize most reactions and quality losses. According to Caleb et al. (2012), fresh food storage can be extended through careful management of atmospheric gases like oxygen, carbon dioxide, and ethylene in storage conditions. To maintain the quality of the fruit, the apple business in North America stores it in facilities with regulated temperatures.

V. FOOD PRESERVATION

Food preservation is the technique of preventing or delaying food degradation and quality loss while extending its edible life. To extend the shelf life of food, food preservation techniques eliminate harmful bacteria from the food and reduce deterioration. Retarding the oxidation of fats that causes rancidity is the aim of food preservation, which prolongs shelf life and lowers the risks associated with consuming the food by preventing the growth of bacteria, fungi, or any other microbes (Amit et al., 2017). Increasing the safety of food products is the primary objective of preservation. If food safety is jeopardized, contamination

may occur, leading to widespread sickness. There are a number of techniques for food preservation that are intended especially for food preservation. To prolong the shelf life of food, traditional procedures are still employed. The next section discusses a few conventional food preservation techniques, including heating, cooling, pickling, boiling, adding sugar, and others (Kumar, 2019).

1. **Freezing:** Two widely employed methods of food preservation in modern times are refrigeration and freezing. Refrigeration is employed with the aim of significantly slowing down bacterial growth to prevent food spoilage.

2. **Pickling:** Pickling is a preservation method where foods are stored in a consumable and antimicrobial liquid, which can be vinegar, vegetable oil, or subjected to anaerobic fermentation. This technique is employed to extend the shelf life of various food items (Behera et al., 2020). There are two main types of pickling: fermentation and chemical pickling. In fermentation, bacteria in the liquid produce preservative agents, while chemical pickling involves preserving food in edible liquids that eliminate microorganisms and bacteria. The pickling process also imparts changes in the texture and flavor of the food. It is a widely practiced method in Asia, where various vegetables like carrots, cauliflower, lemons, and raw mangoes are pickled. North America also pickles items such as eggs, fish, and meat. During pickling, organic acids like lactic acid and acetic acid are produced, acting as preservatives. Brine is another commonly used substance for food preservation. Both acids and brine work to inhibit bacterial growth. A pH level lower than 4.6, which is typically achieved during pickling, is sufficient to eliminate most bacteria, making it a distinctive feature of this preservation method. Pickling allows perishable foods to be stored for several months (Sharif et al., 2017).

3. **Curing:** Vegetables, meat, and fish are preserved using the curing method, which lowers the moisture content through the osmosis dehydration process. Foods like fruits and vegetables can have less moisture content thanks to the osmotic dehydration process, which also lessens the risk of microbial harm (Yadav and Singh, 2014). Food flavor can also be enhanced by the curing process. To do this, add salt, sugars, nitrates, and nitrites. Food products become less rancid when salt is added because it slows down the oxidation process.

4. **Fermentation:** Food fermentation stabilizes and transforms food components by utilizing the development and metabolic activities of microorganisms (Terefe, 2016). Foods made with microbes, such as cheese, wine, and beer, go through a fermentation process. The right temperature, salt content, and oxygen level must be maintained during fermentation in order to cultivate the microorganisms needed to preserve food goods.

5. **Chilling:** Food products are maintained at a consistent temperature range, typically between 1 and 8 °C. This cooling procedure serves to reduce the initial temperatures of the products and maintain their final temperatures over an extended period. Its purpose is to decelerate biochemical and microbial alterations while extending the shelf life of both fresh and processed foods (Sudheer and Indira, 2007).

VI. MODERN METHODS OF FOOD PRESERVATION

1. **Pasteurization:** The application of adequate heat to food items can effectively eliminate the majority of microorganisms and spores. Consequently, high-temperature short time (HTST) and low-temperature short time (LTST) techniques are widely employed for food preservation (Tadini and Gut, 2022).

2. **Vacuum Packing:** DIn the process of vacuum packing, food items are enclosed within a plastic bag, and the air inside the bag is removed to create a vacuum. By storing food in a vacuum where there is no air, microbial growth is inhibited, rendering them unable to thrive. This preservation technique is particularly applied to nuts, as it effectively prevents oxidation reactions like rancidity and helps maintain the flavor of the food items.

3. **Irradiation:** The foods are subjected to radiation or β-particles during this process. Radiation aids in the destruction of germs, mold, vermin, and other microbes. This method is permitted by the Food and Agricultural Organization (FAO) and the World Health Organization (WHO) and is used for fresh fruits, spices, and sauces.

4. **Chemical Preservatives:** Food goods have chemical antibacterial agents added to them for long-term preservation. Small additions of these are made since big additions may be harmful. For instance, in acidic foods like jams, salad dressings, juices, pickles, carbonated drinks, and soy sauce, acids and benzoates are employed to preserve the food. Cheese, wine, and baked goods all use sorbates and acetic acids. Nitrates and nitrites are added to meats to stop the botulinum toxin from occurring. Sulfur dioxide and sulphites are utilized for fruits and vegetables, while propionic acid and propionates are used for baked goods.

5. **Pascalization:** The items are subjected to extremely high pressure throughout this process—70,000 pounds per square inch, for example. This procedure kills the microorganisms while preserving the food's flavor, freshness, texture, and nutrients. Following administration of this therapy, food spoilage rates sharply decline. This method works best with meats and juices.

6. **Biopreservation:** The process of bio-preservation involves the utilization of natural microbes or antimicrobial agents to enhance the shelf life of food products. During this method, fermentation by-products are employed to control and inhibit the growth of microorganisms. Bio-preservatives such as lactic and acetic acid bacteria are utilized in this process. These bacteria produce compounds like lactic acid, acetic acid, bacteriocins, and hydrogen peroxide, which serve as antimicrobial agents to preserve food items. In a study conducted by D'Amico de Alcântara et al. in 2019, the antibacterial activity of Lactobacillus rhamnosus against Pseudomonas fluorescens and Pseudomonas putida, both isolated from refrigerated raw milk, was investigated. These researchers determined that the antibacterial effect is attributed to the presence of organic acids.

VII. CONCLUSION

Food preservation plays a vital role in preventing food loss, enhancing storage stability, and preserving the nutritional value of stored food items. Improperly stored food can

lead to foodborne illnesses when consumed, resulting in financial losses. Approximately 15% of food production is estimated to be lost after the post-harvest stage. Various traditional and modern food preservation methods have been developed. Traditional approaches include pickling, curing, drying, and fermentation, while modern techniques encompass pasteurization, freeze drying, vacuum packing, irradiation, the use of chemical preservatives, pascalization, biopreservation, and modified controlled atmospheres. Both traditional and modern methods contribute to extending the shelf life of foods such as meats, fruits, vegetables, and fish-based products. The selection of a preservation method is typically based on technical and economic feasibility. Additionally, there is growing significance in adopting novel and environmentally friendly packaging methods to maintain food quality during storage.

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