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An Overview of Food Preservation Using Conventional and Modern Methods

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Abstract: This article intends to investigate traditional food preservation methods, as well as their methodical thoughtful, and to propose scientific solutions based on the facts gained. Food preservation is an action or method for preserving foods at the chosen quality level. Several innovative conservation methods are being established to meet contemporary needs for cost-effective preservation as well as user fulfillment in terms of wellbeing, nutrition, and sensory perception. Proper preservation is necessary to keep goods from spoiling for long periods. Preservatives, on the other hand, must not be toxic to humans. There are methods for preventing microbial contamination and lipid rancidity. Foods must also be preserved in terms of nutritional content, texture, and flavor. Traditional preservation techniques such as curing, freezing, canning, boiling, pickling, and many others are briefly discussed in this mini-review, as well as modern practices such as pasteurization, freezing, drying, vacuum packing, radiation, biopreservation, hurdle technology, and modified atmosphere. Modern food preservation has benefited greatly from advancements in packing materials.

Keywords: Pasteurization, Vacuum Packing, Canning, Biopreservation

1. Introduction

Food preservation has become an integral element of the average person's life in the current era. Food preservation is unavoidable for a variety of explanations. Some items, such as fruits and root vegetables, are only available during some seasons and not others, while others are more abundant during certain seasons. There is an excess making of a food product in some regions, while there is an insufficient supply in others.

Food preservation [2, 3] is critical today for a developing country like India to meet its food supply needs. It also assures that the food is always available and that the supply is never depleted. Furthermore, issues such as food scarcity or famine can be avoided.

Food preservation is the act of handling and treating food to prevent deterioration by preventing the attack and growth of food-borne disease-causing microbes, preventing lipid oxidation (rancidity), and preserving the nutritional content, texture, and flavor of the food.

Perishable foods and semi-perishable include juicy fruits, vegetables, mangoes, tomato, papaya, and many others. As a result, civilized beings developed strategies for preserving such seasonal delicacies for later use.

By their very nature, foods are perishable or deteriorative. Major food preservation techniques can be classified into three classes built on their mechanism of action: slowing or suppressing chemical deterioration and bacterial growth; directly deactivating microorganisms, yeast, molds, and enzymes; and preventing recontamination before and after processing.

Chemicals, bacteria from the environment, and enzymes inherent in the food itself are all known to induce food deterioration. Furthermore, food and food products must be delivered from one location to another. There is a risk of food deterioration during travel, as well as loss or reduction in physical attraction and nutritional content. As a result, it is critical to make efforts for food preservation to ensure longer shelf life, consistent quality, morphological appeal, and no change in taste.

Preventing the growth of bacteria, fungus, and other microbes, as well as reducing the oxidation of fats that causes rancidity, are all part of food preservation. Food preservation includes processes that prevent visual deterioration, such as the enzymatic browning reaction in apples after they are cut during meal preparation. Food preservation is all about preserving or generating nutritional value, texture, and flavor.

Many historic food preservation methods, [1, 2] such as preserving fruits by turning them into jams, required less energy and had a lower carbon impact than current procedures. The original procedure entailed boiling the fruits to kill microorganisms and reduce moisture content, adding enough sugar to inhibit microbial regrowth, and sealing them in an airtight container to prevent contamination.

Food preservation has been performed in some form or another since ancient times. At practically every point in history, food preservation was a part of every civilization. Humans must exist in the conditions accessible in their immediate surroundings since they are constantly in contact with nature. Food begins to spoil as soon as it is picked by its nature. Farmers could no longer devour or harvest everything at once, but they could keep some for later.

Food preservation refers to a wide range of methods for preventing food from rotting after it has been harvested or slaughtered. Such customs can be traced back to primordial times. Drying, chilling, and fermentation are some of the oldest ways of preservation. Canning, pasteurization, freezing, irradiation, and chemical addition are all examples of modern processes. [13, 14]

Sun and wind were employed to naturally dry meals in ancient times.

Fruits and vegetables have been dried since the dawn of mankind. For the right temperatures, freezing was also an obvious preservation option. People who lived in a location with freezing temperatures for the portion of the year took advantage of the cold to preserve their food.

In several places of the world, fermentation was also used. It was discovered rather than invented. When a few grains of barley were left in the rain, the first beer was discovered. The starch-derived sugars were fermented into alcohol by microorganisms. Early peoples' ability to notice, harness, and stimulate these fermentations is impressive. Beer was both nutritive and intoxicating. Fermentation not only allowed meals to be preserved, but it also allowed for the creation of more nutritious foods and the creation of more appealing dishes from less desired constituents. It was treated as though it were a divine gift.

Given the reputation of food conservation in reducing the risk of food poisoning and other diseases, various ancient and modern methods for food preservation have been covered here.

Food preservation is essential because we are unable to retain food for long periods without it, resulting in a significant increase in the possibility of famine and food shortages. Dry, pickled, smoked, cellar storage, wine stains, and other traditional methods of food preservation are used. Chemically produced preservatives have become one of the most essential additives in the food business as science and technology progress. As a result, in recent years, the food industry has increasingly used chemical synthetic preservatives to extend the shelf life of food. However, a study found that these chemical synthetic preservatives not only affect the original flavor of food, but also have the potential to cause human-induced cancer, teratogenicity, or food poisoning, as well as other security risks. As a result, people are becoming more worried about food safety and searching for a set of high-performance plant preservatives to replace artificial preservatives. We just discovered several rosemary extracts, propolis, and other substances. Plant extracts have a higher antioxidant capacity.

2. The Importance of Food Preservation Is Summarized in Seven Points

The various foods can be enjoyed in any location and at any time of year.

It is possible to boost the food supply.

Food waste will be minimized.

With proper food preservation, there is no change in the taste, color, or nutritional value of the food.

Food may be tasted from any location, and food can be kept more simply.

Increasing the shelf life of food products.

As a result, using natural food preservatives rather than chemical preservatives will become increasingly crucial in the future, and natural food preservatives will play a significant role in the market.

3. Food Preservation Methods Related to Water Activity and Food Spoilage [3, 4]

The amount of water in food affects its perishability. Concentration and dehydration processes reduce the amount of water in food, making it less perishable and extending its shelf life. Despite these facts, the perishability of various types of food with the same water content varies substantially, showing that water content alone is not a reliable indicator. The difference in the intensity with which non-aqueous elements are coupled to water must be assessed. As a result, the term "water activity" (aw) was coined to describe how water interacts with non-aqueous matter.

Water activity (a_w) is a helpful indication of product stability and microbial safety since it corresponds strongly with rates of bacterial development and several degradative reactions. More microorganisms thrive in environments with higher aw levels. Bacteria need at least 0.91, and fungi need at least 0.7.

Moisture content and water activity affect food breakdown reactions chemically and microbiologically. The water content in dried or freeze-dried foods, which have great storage stability, ranges between 5% and 15%. Foods with a moisture level of 20% to 40% are considered intermediate moisture foods.

Drying or adding water-soluble compounds, such as sugar to jams or salt to pickled preserves, can help reduce water activity. Bacterial growth is nearly difficult below a water activity of 0.9, which is beneficial for food preservation. Between 0.88 and 0.8 water activity, molds and yeasts are frequently suppressed. When the water activity falls below 0.85, most enzymes become inactive.

Lipases, on the other hand, can be active at concentrations as low as 0.3 or even 0.1. The order in which components of the food system come into contact has a substantial impact on enzyme activity, for example, the separation of substrate and enzyme can significantly slow down the reaction.

One of the most important causes driving food spoiling is enzymatic processes such as nonenzymic browning or Maillard reactions. These responses are greatly influenced by water activity, with rates peaking around 0.6 to 0.7. The color change is caused by the browning of milk powder maintained at 40°C for 10 days, which results in the loss of lysine. At low humidity levels, browning processes are usually slow.

Figure 1. *Traditional/Conventional Food Preservation Techniques.*

3.1. Traditional Methods for Food Preservation

3.1.1. Curing [4, 5]

The main notion behind curing goods like meat, fish, and vegetables is to use the osmosis process to reduce the moisture content. When the moisture level of any food is minimal, the possibilities of microbial infection and subsequent growth are greatly reduced. Curing [24] is sometimes used to add flavor. It is accomplished by combining salt, nitrates, sugar, and nitrites in amounts capable of dehydrating the food. The addition of more salt for curing also dehydrates germs, causing them to die. Not only that, but salt can also decrease the oxidation process, resulting in slower fat oxidation and avoiding rancidity.

Dehydration or drying, according to food historiographers, was the first form of cure. Desiccating food was done using salt and smoke processes in earlier civilizations.

By osmosis, salt speeds up the drying process. Some common bacteria are also inhibited by it. Phenols, syringol, guaiacol, and catechol are all found in smoked food. As a result, the food is cured as a result of the process. This method of food preservation was adopted by ancient cultures. It helped them keep their food products fresh, especially when dealing across oceans.

Early cultures were well aware of the benefits of preserving food with honey or sugar. Housewives erudite to produce conserves by the heating system the fruit with sugar in northern locations where there isn't enough sunlight to adequately dry fruits.

3.1.2. Smoking

Smoking [17] is one of the earliest ways of food preservation, having evolved shortly after the invention of fire cooking.

Smoking was one of the first methods of food preservation, appearing soon after the discovery of fire cooking. The so-called natural or health food movement rekindled interest in smoking meats, which had waned throughout the mid-twentieth century due to the prevalence of chemical preservatives.

Smoking temperatures range from 109 to 160 degrees Fahrenheit, and smoking times range from a few hours to several days, reliant on the type of meat and its humidity content. Subsequently smoking, the meat is quickly refrigerated before being chopped and wrapped for retail sale.

It is possible to combine curing with smoking. Smoke dehydrates the meat and covers it with a variety of compounds, including minor levels of formaldehyde. In food processing, smoking refers to the practice of exposing cured meat and fish products to smoke to preserve them and improve their palatability by enhancing flavor and giving them a rich brown color. Although many of the compounds included in wood smoke are natural preservatives, the aeration action of the smoke tends to preserve the meat.

Figure 2. *Smoking process of meat to remove moisture.*

3.1.3. Pickling and Health Hazards

Pickling, [5, 6] which is a method of preserving food in vinegar, was another well-known preservation technique used by our forefathers. There are a variety of traditional methods for extending the shelf life of goods, such as soaking them in vinegar or vegetable oil or using anaerobic fermentation. This process alters the texture, flavor, and taste of the food.

Pickling [4] is the anaerobic fermentation of food in brine or vinegar to preserve it. This process imparts a salty or sour flavor to the dish. Vinaigrette (vinegar and vegetable oil) is the pickling medium in South Asia. Brine, vinegar, alcohol, and vegetable oil, particularly olive oil but also a variety of other oils, are common pickling agents. Mango, cucumber, green chili, lemon, and 'Amla' are some of the most common pickles created. Many vegetables, such as carrots, cauliflower, lemon, and raw mangoes, are pickled in Asian countries, including India. Pickles of eggs, fish, and beef, among other things, are eaten in several European countries, Canada, and the United States. In Asian countries, anaerobic fermentation of vegetables and fruits such as mangoes, radish, and carrots is also widespread.

Pickling is a great way to keep perishable goods fresh for months. Herbs and spices with antimicrobial properties, such as mustard seed, garlic, cinnamon, and cloves, are frequently used. If there is enough moisture in the food, a pickling brine can be made simply by adding dry salt.

Figure 3. *Packed pickling foods.*

Unlike canning, [8, 14] pickling does not necessitate sanitization of the food before sealing. The acidity or salinity of the solution, the fermentation temperature, and the lack of oxygen all have an impact on which bacteria are dominant, as well as the end product's flavor.

Before being employed in chemical pickling, the jar and lid are sterilized. The pickled fruits or vegetables are then combined with brine, vinegar, or both, as well as spices, and fermented until the desired flavor is attained.

Before transferring the item to vinegar, it can be pre-soaked in brine. This cuts down on the food's water content, which would otherwise dilute the vinegar. This approach is very effective for fruits and vegetables that contain a lot of natural water.

A preservative like sodium benzoate or EDTA can be added to commercial pickling to lengthen its shelf life. In fermentation pickling, the food produces the preservative agent, usually through a process involving "Lactobacillus" bacteria that produce lactic acid as the preservative agent.

Pickled vegetables are recognized as a potential carcinogen by the World Health Organization, and a meta-analysis of evidence published in the British Journal of Cancer in 2009 concluded that pickles increase the risk of esophageal cancer. According to the findings, Asian pickled vegetable consumption is linked to a two-fold increased risk of oesophageal cancer.

3.1.4. Canning [8] and Problems Associated

Canning is an important and safe method of food preservation when done appropriately. Canning [5, 6] is preparing food, sealing it in sterilized cans or jars, then boiling the containers to destroy or weaken any bacteria that may remain. Foods have variable levels of natural protection against spoilage; thus the final step may need to be done in a pressure cooker.

Although most people associate "cans" with metal, any sealable container can be used as a can. Boiling and sealing glass jars, for example. Pouches and boxes made of foil or plastic can also be used. "Canned" milk is milk that comes in a box and can be stored on a shelf. The milk in the box has been pasteurized at an ultra-high temperature (UHT) and sealed inside the box to prevent spoilage even at room temperature.

Food is heated in jars or other containers to destroy bacteria that cause food to spoil. The air is driven out of the jar during the heating process, and as it cools, it forms a vacuum seal. This vacuum seal keeps air out of the product, which would otherwise contaminate it with microorganisms. Food can be safely processed using either a boiling water bath or a pressure canner.

Tomatoes, fruits, jams, jellies, pickles, and other preserves can all be cooked in a boiling water bath. Food jars are heated entirely covered with boiling water and cooked for a set amount of time using this method. [13]

The only safe way to preserve vegetables, meats, poultry, and shellfish is to use pressure canning. Food jars are submerged in 2 to 3 inches of water in a special pressure cooker that has been preheated to at least 240° F. The only way to get to this temperature is to use the pressure method. Pressure canning is required for foods with a minimal acid content, such as vegetables and meats. Canned foods, on the other hand, spoil quickly after being opened in the can or bottle.

Nicolas Appert, a French confectioner, pioneered the process of canning for prolonging the shelf life of products in the early nineteenth century. Cooking the food, then sealing it in sterilized jars or cans, and boiling the containers for sterilization are all part of the procedure. Any residual microbe is killed or weakens under these conditions.

Once a can or bottle has been opened, food conserved by canning or bottling is immediately at risk of deterioration. Water or microorganisms may enter the canning process due to a lack of quality control. The majority of these failures are quickly discovered because disintegration within the can produces gas, causing the can to bulge or burst. Though, there have been cases where poor manufacturing and cleanliness have allowed the obligate "anaerobe" Clostridium [2] botulinum to contaminate canned food, producing an acute toxin that causes serious disease or death.

Canned foods can be a substantial basis for sodium in the food. Excess salt raises the likelihood of health issues, such as high blood pressure.

3.1.5. Fermentation

Fermentation is the biochemical change of sugars into ethanol, which is used to manufacture fermented drinks such as wine, cocktails, and apple juice.

Fermentation is the anaerobic conversion of carbohydrates to alcohols, carbon dioxide, or organic acids in food processing utilizing yeasts, bacteria, or a combination of both. Fermentation is a metabolic process that converts sugar to acids, gases, and/or alcohol. It's found in yeast, bacteria, and oxygen-depleted muscle cells, as well as in lactic acid fermentation. The term "fermentation" [16] is also used to describe the rapid growth of microorganisms on a growth medium. Fermentation is also employed in bread leavening, the preservation of sour foods like sauerkraut, dry sausages, kimchi, and yogurt, and the vinegar pickling of goods.

Figure 4. *Packed canned foods.*

Controlled variables such as salt, temperature, oxygen level, and other factors are maintained throughout fermentation to assist the fermentative microorganism in producing a food product fit for human consumption.

Fermentation is the cell's primary source of ATP in the absence of oxygen. NADH and pyruvate, which are produced during glycolysis, are converted to NAD+ and other small molecules. In the presence of oxygen, NADH and pyruvate are employed in respiration; this is referred to as oxidative phosphorylation, and it generates far more ATP than glycolysis. As a result, cells prefer to avoid fermentation when oxygen is available.

Although microbes are commonly associated with spoiling, they can also provide positive effects under certain conditions, such as oxidative and alcoholic fermentation. Acidity, accessible carbohydrates, oxygen, and temperature all influence the microbes that grow in a food product and the changes they generate. Salting is a common food preservation process that combines selective microbe control with fermentation to preserve the treated tissues.

3.1.6. Salting [10]

Since ancient times, salting has been one of the most extensively utilized food preservation methods. Salting [1, 2] is the process of covering food that has to be preserved with salt. Because the concentration of salt in water as a solvent is very high outside the salt-covered body, which is practically one, the concentration of salt inside the food body is almost one. This causes a concentration difference between the two portions, resulting in the mass transfer of water molecules from the food's body cells to the outside of the body, a process called osmosis. It reduces the amount of water in the diet. The overall water activity of the food product is reduced when the water content of the food product is reduced. It inhibits a wide range of biochemical and enzymatic reactions, as well as microbiological growth. The food product will not spoil as a result of this.

Figure 5. *Salted Foodstuff.*

3.1.7. Boiling

It is a common practice in developing nations to boil water to destroy any microorganisms that may be present, and then cool it to room temperature before consuming it. It is also common to boil milk (even pasteurized milk) before drinking it to kill any bacteria that may be present.

3.1.8. Sugaring, Drying, and Its Benefits

Sugar is still used as a preservative in the preservation of certain goods. The main mechanism of action is that high sugar content causes hypertonicity in foodstuffs, and bacteria cannot survive in hypertonic solutions because the hypertonic solution draws water from the bacterium, causing it to become dehydrated. Fruits are frequently stored in honey or sugar. Sugaring can also be found in jams and jellies. This technique is also used in the preparation of certain soft drink concentrates, such as orange squash, which has high sugar content.

Figure 6. *Packed Sugared foods.*

Jellies and other fruit preserves are made by adding sugar to fruit and concentrating it through evaporation to a point where microbiological deterioration is impossible. Although hermetic sealing is important for controlling mold development, moisture loss, and oxidation, the produced product can be stored without it. Vacuum sealing has largely supplanted the use of a paraffin cover in modern practice.

Drying is the process of eliminating water from food to preserve it. Foods can be dried using a variety of methods, including sun drying, air drying, heat drying, wind drying, and drying over an open fire. Removing water stops decay and microorganisms from growing. Since ancient times, this method of food preservation has been used.

The drying principle is based on water activity: the lower the water activity, the longer the food product's shelf life. Dehydration lowers the water content of food, lowering water activity and extending shelf life.

Figure 7. *Dry Fruits and nuts.*

Water is required for the growth of molds, yeast, and bacteria. Microorganisms cannot develop and foods do not deteriorate when foods are adequately dehydrated. Dry fruits and fruit leathers can be eaten as snacks, and dried veggies can be used in soups, stews, and casseroles. Dried foods are preferred by campers and hikers because of their minimal weight, long shelf life, and ease of preparation.

Because dried fruits contain concentrated fruit sugars, they are a good source of energy. Fruits also have a high concentration of vitamins and minerals. However, the drying process eliminates several vitamins, particularly A and C. Sulphur treatment of fruit before drying aids in the preservation of vitamins A and C. Sulphur degrades thiamine, a B vitamin, yet the fruit isn't a good source of thiamine in the first place. Riboflavin and iron are abundant in dried fruits.

Minerals and the B vitamins thiamine, riboflavin, and niacin are abundant in vegetables. Fiber is found in both fruits and vegetables at insufficient levels. Save the water used to soak or cook dried items since it contains nutrients that can be utilized in soups, sauces, and gravies.

3.1.9. Low-Temperature Preservation (Freezing and Refrigeration)

The oldest methods of food preservation using natural low temperatures include cooling and freezing. The ammonia refrigeration system, which could support commercial refrigeration and freezing of foods, was invented in 1875. The contemporary frozen food sector exploded in popularity starting around 1920. Food Preservation Methods today have a significant impact on marketing and food business practices, as well as the economic climate in the agro-food industry.

The temperature of the food is decreased below the freezing point, and a part of the water changes state to form ice crystals, resulting in a concentration of dissolved solutes in unfrozen water and lowering the water activity (aw) and pH values. Low temperatures, reduced water activity in some foods, pre-treatment by blanching, and microbe growth retardation are all used to preserve food.

Chilling is a method of increasing the shelf life of both fresh and processed goods by slowing down biochemical and microbiological processes. Chilling stops thermophilic and many mesophilic bacteria from growing. A variety of bacteria can proliferate after long periods of refrigerated storage below 5°C or as a result of any temperature increase, resulting in food poisoning. However, it is now understood that at these temperatures, several pathogenic species can either proliferate in large numbers or become sufficiently virulent to cause poisoning after only a few cells are swallowed.

Refrigeration and freezing are the most widely used methods of food preservation today. In the case of refrigeration, the goal is to delay bacterial action to a crawl, allowing food to degrade over a longer period. When it comes to freezing, the goal is to completely inhibit bacterial activity. Bacteria that have been frozen are inert. Freezing and refrigeration work on the same principles. Many biochemical activities and bacterial and fungal growth are decreased or stopped when water is frozen or refrigerated, as well as when the temperature is reduced.

Food is frozen by lowering the temperature below 0 degrees Celsius, causing the water in the food to convert into ice gradually. Freezing is a crystallization process that begins with the formation of a nucleus or seed from a nonaqueous particle or a cluster of water molecules (which occurs when the temperature falls below 0°C). To provide a favorable environment for the crystal to grow, this seed must be of a specific size. If the physical conditions are conducive to the formation of a large number of little ice crystals, a large number of them will develop. If there are only a few seeds, a few ice crystals will form at first, each growing to a large size. Many frozen foods' final quality is influenced by the size and number of ice crystals present; for example, the smooth texture of ice cream suggests the presence of a significant number of little ice crystals.

The freezing of food differs significantly from the freezing of pure water in several ways. At 0 degrees Celsius, food does not freeze. Instead, most foods begin to freeze at a temperature between 0 and 5°C due to the presence of various soluble particles (solutes) in the water present in foods.

Cryogenic freezing is a technique for rapidly freezing food. The meal is either sprayed with liquid nitrogen or soaked in liquid nitrogen directly. At a temperature of 196°C, liquid nitrogen boils around the food, extracting a considerable amount of heat.

Freezing [15] and Refrigeration Cause Textural Changes. Most fruits and vegetables contain more than 90% water by weight. Water and other chemical components are kept within the somewhat hard cell walls that provide the fruit or vegetable support, structure, and texture. When you freeze fruits and vegetables, you're freezing the water inside the plant cells. When water freezes, it expands, causing the cell walls to break due to ice crystals. Destabilization of emulsions, flocculation of proteins, increased hardness of fish flesh, loss of textural integrity, and increased drip loss of meat are all examples of changes that can occur when foods are frozen.

Figure 8. *Freeze meat.*

Freezing and Refrigeration Cause Chemical Changes. The development of rancid oxidative tastes in frozen food is a chemical alteration that can occur when the frozen product comes into contact with air. This issue can be avoided by utilizing a wrapping material that prevents air from entering the package. To decrease the quantity of air in contact with the goods, it's also a good idea to remove as much air as possible from the freezer bag or container.

3.2. Blanching

Blanching [10] is a heat treatment that is applied to vegetable tissues before freezing, drying, or canning. Blanching is used before canning for a variety of reasons, as well as cleaning the product, lowering the microbial load, releasing any trapped gases, and wilting the tissues of leafy vegetables so they may be readily placed into the containers. Blanching also inactivates enzymes that cause food to deteriorate while stored in the freezer.

Blanching is done in a water bath or a steam chamber at temperatures near 100°C for two to five minutes. Because steam blanchers utilize so little water, great caution must be exercised to ensure that the product is evenly exposed to the steam. Leafy vegetables are particularly difficult to steam blanch because they tend to clump together. The residual activity of an enzyme called peroxidase is commonly used to determine the efficiency of the blanching process.

4. Chemical Preservation [16]

Chemical food preservatives are compounds that, underneath specific environments, also inhibit the growth of germs without essentially killing them or preventing quality degradation during production and distribution. Some natural dietary elements that, when added to foods, impede or prevent the growth of microbes are included in the first group. Sugar is used in the preparation of jams, jellies, and marmalades, as well as in the candying of fruit. This includes the use of vinegar and salt in pickling, as well as the use of alcohol in brandying. To prevent the growth of microbes, some chemicals that are not found in foods are added. The latter group includes some natural food elements, such as ascorbic acid, which is added to frozen peaches to prevent browning, as well as a wide range of artificial chemicals.

4.1. Organic and Inorganic Chemical Preservatives

The main chemical preservatives are sodium benzoate and various benzoates. Most nations allow the use of benzoates in certain products in a defined amount however, others require notification of their usage on the food container's label. Because free benzoic acid is the active ingredient, benzoates must be utilized in an acidic environment to work. Cranberries' capacity to withstand rapid deterioration is due to their high benzoic acid content. Molds and bacteria are more susceptible to benzoic acid than yeasts. Vanillic acid esters, monochloroacetic acid, propionates, sorbic acid, dehydroacetic acid, and glycols are among the other organic compounds employed as preservatives.

The most common inorganic chemical preservatives are sulfur dioxide and sulfites. Sulfites are used to preserve fruits and vegetables because they are more efficient against mold than yeasts. Sulfur compounds are widely employed in winemaking, and as with most other uses of this preservative, great care must be taken to maintain concentrations low to avoid unfavorable flavor effects.

4.2. Pasteurization

Pasteurization [12] is the technique of killing pathogenic bacteria, inactivating spoilage-causing enzymes, and reducing or eliminating rotting microorganisms in food by employing heat. The comparatively modest heat treatment employed in the pasteurization process causes little alterations in the sensory and nutritional characteristics of foods when compared to the high heat treatments utilized in the sterilization process. The temperature and time requirements of the pasteurization process are influenced by the pH of the food. Pasteurization primarily targets spoilage bacteria and enzymes when the pH is below 4.5.

4.3. Modified and Controlled Atmospheres Are Used for Preservation

Modifying the atmosphere [13] is a method of preserving food by manipulating the environment around it. Salad crops, which are notoriously difficult to store, are now packaged in sealed bags with an atmosphere that has been altered to minimize oxygen (O_2) and increase carbon dioxide (CO_2). Although salad veggies preserve their appearance and texture under these conditions, there is concern that nutrients, particularly vitamins, may be lost. Grain preservation with carbon dioxide can be accomplished in two ways. Placing a chunk of dry ice in the bottom of the can and filling it with the grain is one way. Another option is to use gaseous carbon dioxide from a cylinder or bulk supply vessel to purge the container from the bottom. They're primarily utilized for bulk storage and transport. To ensure optimal conditions for the long-term preservation of fruit, meat, and other items, the gas composition, humidity, and temperature can all be regulated.

Gas Packaging

For bulk storage and retail packing, this method is employed. It is necessary to employ gas mixes. The gas level of CO_2, O_2, and N_2 may alter during storage as a result of pack permeability, the biological activity of the packed product, and chemical reactions, such as oxygen with some food components like vitamin C.

Vacuum packaging [13] is another method. This strategy is most commonly utilized in retail packaging. The original air atmosphere is removed, and the atmosphere that emerges during storage is primarily the consequence of the products' biological activities.

Figure 9. *Vacuum Packed food items.*

4.4. Irradiation Preservation of the Foods and Negative Effects

Food irradiation is the process of irradiating [23] food with high-speed electron beams or high-energy radiation with wavelengths shorter than 200 nanometers, or 2000 angstroms (e.g., X-rays and gamma rays). These beams have enough energy to break chemical bonds and ionize molecules in their path. The two most common high-energy radiation sources used in the food industry are cobalt-60 (60Co) and cesium-137. Gamma rays have a better penetrating power into meals than high-speed electrons at the same energy level.

Self-life extension via avoiding sprouting in potatoes, onions, and garlic at 0.2-0.15 kGy; delaying ripening and senescence in bananas, avocados, papayas, and mangoes at 0.15-0.50 kGy;

Delaying microbiological decomposition of fruits and vegetables; extending the shelf life of beef, poultry, and shellfish by destroying spoiling bacteria; Pasteurization of seafood, poultry, and beef at low doses To sanitize the chicken, spices, and seasonings, use a bigger amount. Improvements in product quality, such as using a 7.5 kGy dose to reduce the requirement for nitrate during the manufacturing of some meat goods; reduction in the need for nitrate during the manufacturing of some meat items.

When lipids are radiolyzed in the absence of oxygen, the interatomic bonds in the fat molecules are cleaved, resulting in carbon dioxide, alkanes, alkenes, and aldehydes. Furthermore, lipids are very susceptible to free radical oxidation, which produces peroxides, carbonyl compounds, alcohols, and lactones. The rancidity that results from irradiating high-fat meals is extremely detrimental to their sensory quality. Fatty foods must be vacuum-packed and kept at subfreezing temperatures during irradiation to avoid such adverse consequences.

4.5. Potential Food Preservation Methods

4.5.1. Pulsed Electric Fields [6]

Microorganisms are inactivated by a shock wave generated by an electric arc, which causes highly reactive free radicals to develop from diverse chemical species in the food. In general, researchers have discovered that increasing the electric field intensity and the number of pulses causes bacteria to become inactive. Microorganisms may be killed as a result of pores forming in cell membranes.

4.5.2. High Pressure

High-pressure [7, 11] food preservation, also known as pascalization, is a food preservation technique that uses high pressure. "Food can be processed so that it retains its fresh appearance, flavor, texture, and nutrients while disabling harmful microorganisms and slowing spoilage by being pressed inside a vessel exerting 70,000 pounds per square inch or more."

Hydrostatic pressure technology [6.7] is a non-thermal food processing method in which foods are subjected to high hydrostatic pressure at or near room temperature, often in the range of 100-600 MPa. In general, pressures between 400 and 600 MPa inactivate vegetative microbiological forms, although spores in particular areas may withstand pressures more than 1000 MPa at ambient temperatures.

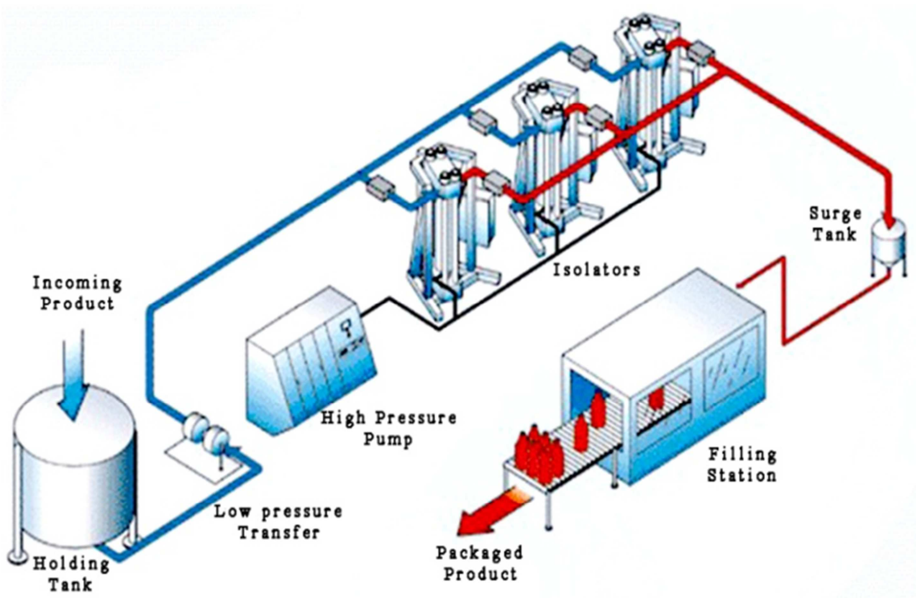

Figure 10. *High-pressure food packing.*

With different bacteria, the patterns of high hydrostatic pressure inactivation kinetics are quite diverse. In the case of certain bacteria and yeast, some researchers have discovered first-order kinetics. Other researchers noticed a shift in the slope as well as a two-phase inactivation event, in which the initial part of the population was rapidly inactivated while the second was much more resistant. The patterns of inactivation kinetics are influenced by pressure, temperature, and the content of the media.

4.5.3. Ultraviolet Radiation [18, 23]

It is commonly known that UV light may be used to kill germs in the water. This type of radiation is safer, more environmentally friendly, and less expensive to install and run than traditional chlorination. Unlike chlorine, it does not affect the flavor of the water. High-intensity UV-C [21] lamps have recently become accessible, with the ability to kill surface microorganisms on food.

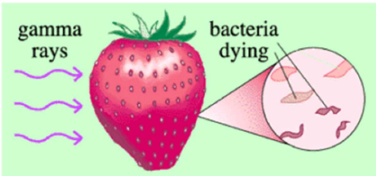

Figure 11. *Light treatment to kill bacteria in fruits and vegetables.*

Commercially, ultraviolet irradiation [18, 23] is used in a variety of food applications, such as tenderizing meat, curing and wrapping cheeses, preventing surface mold growth on bakery products, and air purification in bottling, and food processing facilities, and over pickle vats, using bactericidal ultraviolet lamps.

4.5.4. Biopreservation [19]

The use of natural or controlled microbiota or disinfectants to preserve food and extend its shelf life is known as biopreservation. [10, 12] Food biopreservation, particularly the use of lactic acid bacteria that suppress food deterioration germs, has been performed since the dawn of time, initially unknowingly but gradually with a growing scientific base. To limit degradation and render pathogens inactive in food, biopreservation uses helpful bacteria or the fermentation products produced by these bacteria. Organic acid production, which results in a drop in pH and the antibacterial activity of the un-dissociated acid molecules, a wide range of small inhibitory chemicals, such as hydrogen peroxide, and so on are some of the processes by which microorganisms might prevent others from growing. It's a common ecological strategy that's not detrimental to the environment.

4.6. Combined/Hybrid Methods for Food Preservation

Hurdle Technology [22]

A better understanding of the hurdle effect led to the development of hurdle technology, which allows for advances in food safety and quality through the use of a planned and clever mix of hurdles. Leistner (2000) defines hurdle technology as an intelligent combination of obstacles that ensures food product microbiological safety and stability, as well as organoleptic and nutritional quality, and economic viability. The sensory aspects of food, such as appearance, taste, smell, and texture, are referred to as organoleptic quality. Hurdle technology is of practical significance in rich countries for minimally processed foods; nevertheless, in developing countries, items that can be preserved without refrigeration due to hurdle technology stability are currently of critical value. The application of intelligent and purposeful obstacle technology is rapidly expanding around the world. This notion is referred to as "food preservation by integrated procedures, combined processes, a combination of preservations, or a variety of techniques. The term "hurdle technology" is now often used.

Most traditional and innovative foods' microbiological stability and safety are based on a combination of preservation elements that microorganisms present in the food are unable to overcome. Because barriers in a stable product regulate microbial decomposition, food poisoning, as well as beneficial fermentation processes, the hurdle effect is critical for food preservation. In truth, the hurdle notion just demonstrates the well-known fact that the intricate interplay of temperature, water activity, pH, redox potential, and other factors have a role in food microbiological stability. The link between technology and microbial homeostasis is well-established. This method of food preservation is safe, stable, healthy, flavourful, and cost-effective.

Pathogens in food products can be eradicated or controlled with the use of hurdle technology. This means that the food goods will be safe to eat and will have a longer shelf life. Typically, hurdle technology employs a combination of approaches. These methods can be viewed as "barriers" that the virus must overcome to stay alive in the meal. All infections can be eradicated or rendered harmless in the final product if the proper set of obstacles is used.

5. Conclusion

Food preservation [3] has always been and will continue to be an important aspect of everyday living for ordinary people. It prevents a big amount of food from being wasted all around the world. When it comes to foodborne infections caused by consuming damaged food, adequate food preservation is critical. Even though many present procedures for food preservation are functional and safe, more effective and safer solutions must be sought to maintain economic viability and social responsibility. Food preservation, including commercial packaging, has a wide range of applications. More research in this direction is required.

There are still plenty of fruits, vegetables, herbs, spices, meats, and seafood in the area. As a result, the old culture of food preservation has survived and thrived to the present day.

Many people still use these old-fashioned food preservation methods, and it's hardly rocket science.

Traditional food preservation should be promoted to the general public through public awareness, drives, sessions, and weekly articles. and new industries should be established to aid in the promotion of traditional ways. Traditional methods can be updated by using scientific involvements where possible, which will benefit not only the general public and government but also forthcoming groups.

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