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MODERN TRENDS AND TECHNIQUES FOR FOOD PRESERVATION

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Abstract: Food preservation is the process of stopping or inhibiting the spoilage of food that prohibits foodborne diseases while keeping the food's nutritional value, flavor, and texture. Food preservation plays a vital role in food safety and quality. Food preservation techniques are also helpful in meeting the global food demand as these techniques provide an opportunity to store food for a long time. Food safety techniques, like salting, drying, and fermentation to increase the shelf-life of raw food, have been used since the dawn of humankind, and our ascendants must have used these techniques. A wide range of chemical and biochemical reactions could be the root of food spoilage. So, appropriate preservation is necessary to stock the food for as long as possible without contamination. Primary and fundamental techniques like drying, freezing, pasteurization, biopreservation, and Nanoencapsulation have been instigated to stop or slow down food's chemical and biochemical destruction. Bio-preservatives are now commonly used to meet people's demand for food preservation as chemical preservatives are rejected. This review summarizes the various physiochemical and microbial components that cause food spoilage and the use of different food preservative techniques like salting, dehydration, freezing, smoking, irradiation, antimicrobial agents, preservatives, and nanotechnology in the food industry during processing and packaging.

Keywords: food spoilage; food preservation; biopreservatives; nanotechnology; food processing

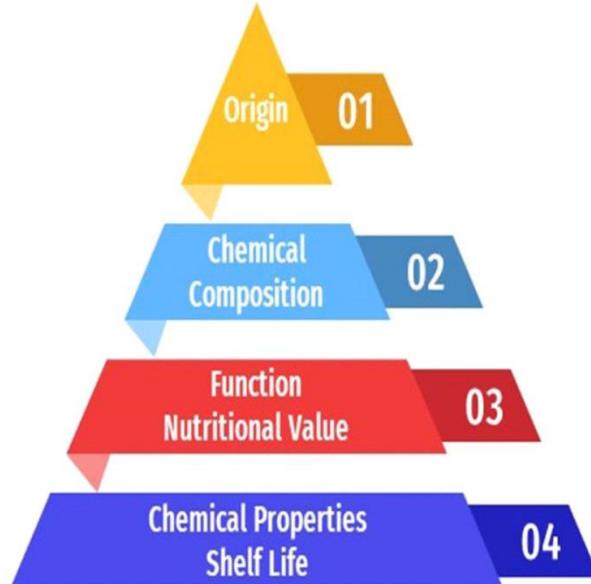
Introduction. Food is an organic substance that can be in solid or liquid form and can be absorbed, digested, and assimilated in the body of an organism to gain the energy that the body needs to work, repair tissue, grow, and perform other vital processes. It consists of all the essential nutrients like proteins, fats, carbohydrates, vitamins, and minerals. It can be obtained from animal or plant sources. The demand for food production is rising remarkably due to increasing population and changes in food diversity. As foods are nutritious enough, they can be spoiled by physical, chemical, and microbial



processes (Rahman and Labuza, 2007). According to the World Health Organization (WHO), about 1 out of 10 people become ill from eating spoiled food. According to Fouladkhah et al. (2019), 420,000 people die every year due to food poisoning. It has been observed that during food transportation, the surrounding environment, including bacteria, chemicals, and the enzymes present in food, can cause changes in the morphology of food and reduction of nutrients in food (Gram et al., 2002). Thus, the food needs to be preserved to avoid spoilage by contamination and maintain food quality. Food preservation increases food stock storage and shelf-life without affecting nutritional values and qualities (texture, aroma, freshness, flavor, color). Food Preservation is also helpful in avoiding the oxidation of fat in food by inhibiting microbial growth (Prokopov and Tanchev, 2007). Food preservation is also known as food processing (Lianou et al., 2016; Necidová et al., 2019). The history of "Food Preservation" goes back to ancient culture when primary troops felt that there was a need to preserve food when a large animal could not be eaten at once. Similar basic techniques were applied to keep food in a distant society, which was the utmost evolutionary step (Nummer, 2002).

The food industry is trying to design new, less invasive technologies (use of high pressure, hurdle technology, radiations like UV light, Oscillating Magnetic Field) beyond the traditional conventional methods like drying, freezing, chilling, curing, heating, boiling, sugaring, salting, canning, pickling, and fermentation (Blum, 2012; Rahman, 2014). Bio preservatives are alternatives for preserving food to keep its characteristics, which is also helpful in fulfilling the demands of people who want to consume chemical-free food. Bio-preservation is a technique used to control microbes by adding natural antimicrobial compounds to increase the shelf-life of food products. It also uses beneficial bacteria to prevent spoilage and make pathogens inactive. Bio preservatives act by lowering the pH, changing the water activity, and adjusting the redox potential of food products (Rehman, 2020). Lactic acid bacteria (LAB) are widely used to preserve food (Gemechu, 2015).

Classification of Foods. Food classification is done on various occasions, as discussed in Fig. 1 and further explained below.



Food classification based on shelf-life

There are three classes of food based on the shelf life of food (Perishable foods, Non-perishable foods, Semi-perishable foods).

Food classification based on functions

Based on the functionality of food, they can be classified into two classes.

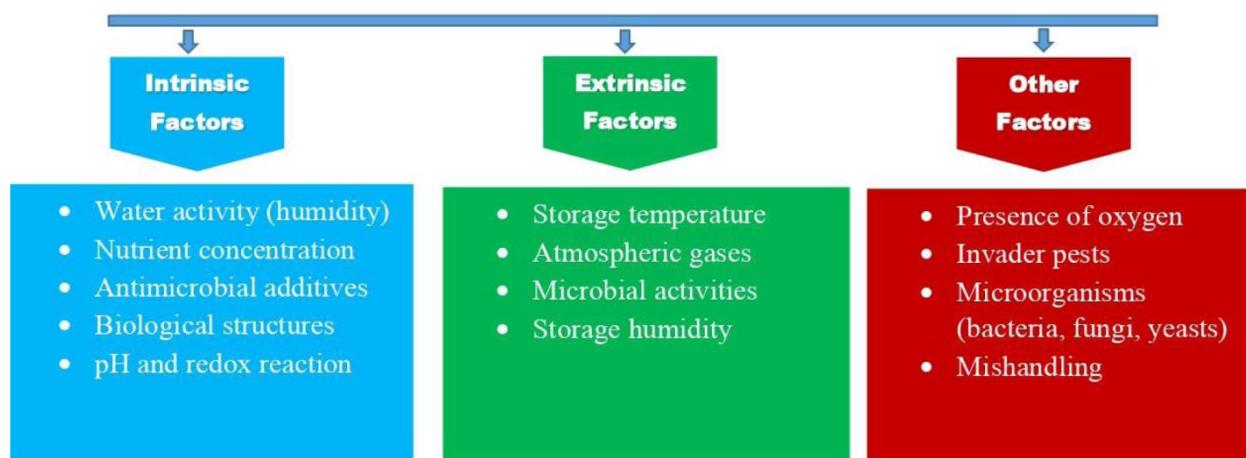
i) Bodybuilding and repairing foods, ii) regulatory and protective food, iii) energetic foods.

Bodybuilding and repairing foods

Food Spoilage Mechanism

The process that causes the reduction of food nourishing ability is known as food spoilage and is related to food safety (Steele, 2004). The extent of food spoilage can be determined by chroma, aroma, flavor, and taste. The mechanism of food spoilage is elaborated in the Fig. 2. Various factors that are the cause of food quality and causing food spoilage are explained below.

Fig. 2. Factors affecting food quality and causing food spoilage.



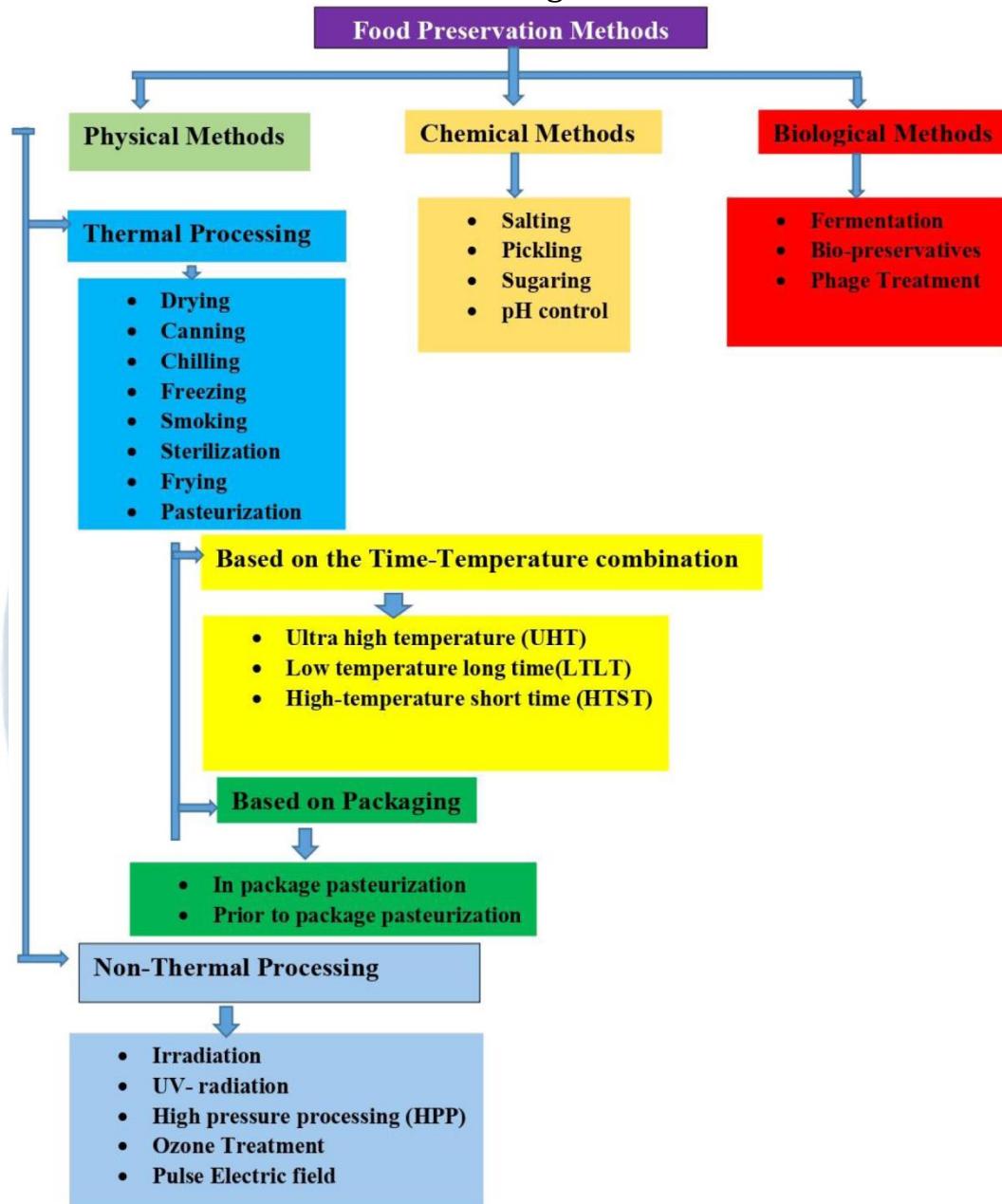
Microbial spoilage. It is the most common method of food deterioration. Microorganisms like bacteria, fungi, molds, and yeasts cause food deterioration and foodborne illnesses, especially in highly perishable foods. It can be prevented by lowering pH, controlling water activity, adjusting temperature, properly packaging, and using preservatives (Tianli et al., 2014). Nutrient concentration, water content, pH, and redox reactions are intrinsic factors of food spoilage (Steele, 2004). Meanwhile, humidity, temperature, and the presence of microorganisms are extrinsic factors (Steele, 2004). Antibiotic resistance is the major issue while microbial Spoilage can be controlled by antibiotics (Samad, 2022). So, we need to use an alternative to stop microbial spoilage.

Chemical spoilage. Physiochemical and biochemical reactions naturally occur in food, which may cause color, odor, texture, and taste changes. Microbial activity and metabolism, redox reactions, proteolysis (Igarashi et al., 2007), hydrologic rancidity (Steele, 2004), putrefaction, and toxic compound production are factors that cause chemical spoilage of food.

Dehydration. Dehydration or drying is the process of removing all the water content from the food items. The process of evaporation is used for drying purposes. It is one of the oldest preservation methods. After dehydration, microorganisms' growth is inhibited; they cannot cause spoilage as all the enzymes work at specific water activity, while in this process, moisture is lowered to the point where their functionality is lost. Most microbes grow at 0.95 water content and do not grow when water is lowered to 0.88 (Troller, 1986). It has diverse advantages, as lowering the density and quantity of food is the cheapest way to preserve food and making it easy to transport, store, and pack food. However, it also causes loss of aroma and flavor, vitamin C, proteins, lipids, and thiamine in dehydrated food products. Drying and freeze-drying methods preserve fruits, fish, vegetables, coffee, and tea.

Food Preservation Methods

There are several food preservation methods, which are explained below and also shown in the flow chart Fig. 3.



Physical methods

Pasteurization is a process in which food is heated to destroy all types of bacteria and enzymes (Shenga et al., 2010) to extend the shelf life of food items and keep them fresh for a longer period (Vieira et al., 2018). This process kills almost all pathogenic bacteria, yeasts, and molds, but the temperature and duration should be optimal. They must not destroy the vitamins and proteins of foods. This process is known to French scientist Louis Pasteur, who used this technique for the first time to preserve milk and



milk products. Wine and beer are also treated by this process. Modern procedures like low-temperature long time (LTLT), high-temperature short time (HTST), and ultra-high temperature (UHT) are also accessible. LTLT is done on small plants. This process must control proper holding and prevent overheating or burning (Rahman and Labuza, 2007). HTST is done to perish the pathogenic microorganisms. It is a continuous "Flash Pasteurization". UHT is done to restrict heat-resistant spores and is more effective than LTLT and HTST. Foods are heat-treated and aseptically packed in sterile containers. High heat treatment pasteurization causes a loss of 20% of vitamin C, 10% of thiamine and vitamin B12, and 5% of calcium and soluble phosphorus, but this loss can be considered lower from a nutritional point of view

Freezing. Freezing is an ancient method that reduces the physiochemical and biochemical reactions and thus inhibits or deteriorates the growth of pathogenic. This method is preferable over canning and dehydration because it is effective for the long-term preservation of food and reduces metabolic responses (Fennema et al., 1973). In this method, water activity is reduced, and the temperature is reduced to 18°C or lower (Fennema et al., 1973). Though they have a vigorous and effective capacity to control pathogens, frozen foods are not acquired in developing countries. So, it is not widely used in industrial food preservation, but in upper-class and uptown, freezers are widely used (Amit et al., 2017). In recent years, freezing has been widely used to preserve fruits, vegetables, and meat. Meat contains 50%-75% water; it is converted into ice cubes in the freezer, which occurs at -20°C.

Irradiation. Irradiation is the physical method of food preservation which results in disinfection, inhibition of sprouting, inactivation of pathogenic microbes, and increasing the safety of grains, vegetables, fruits, and other food goods (Heldman and Moraru, 2010; Kanatt et al., 2006).

This process uses ionizing radiation (IR) of specific strength to destroy the microbes of frozen food. Gamma rays, X-rays, and ultraviolet rays (UV) are natural IR; Electron beams, which are artificial sources of IR, are used for this purpose. Vitamins, minerals, carbohydrates, and protein in food products are not affected at all by this process, but a minute amount of vitamins A, C, E, and B1 may be loosened.

Packaging. Packaging is placing minimally processed or completely processed foods into paper, plastic, or metal containers. This technique is becoming foremost because it is used to transport food from factories to sailing points with minimal changes in the characteristics of food. It preserves vegetables, fruit juices, and dairy products (Alvarez et al., 2014). Packaging materials may interact with food inside, so coatings of bio-edible films are



used to inhibit pathogenic effects and reduce the harmful interactions between materials and food. For instance, glycerol can be used to preserve potatoes by dipping them in it, and sorbitol or oil corn can be used for cheese protection.

Nanoencapsulation is a technique that is mainly used for packaging solid or liquid food in nanocapsules (called shells) (Bratovcic and Suljagic, 2019). It helps the release of packed (canned) food flavor continuously during food storage. This method is not significantly used in developing countries but has various beneficial applications for food preservation in developed countries. Heating is done before packaging proteins – foods are heated and packed in cans or jars, but plant-extracted food items should not be preheated to canning.

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