

Progress In the Application of Food Preservatives in Food

Ziya Peng

SESCIE International School, Shanghai, China

* Corresponding Author Email: wuyan@ldy.edu.rs

Abstract. Food preservatives are compounds that are either naturally occurring or chemically created and added to food to improve its flavor, color, and fragrance, or to prevent food from deteriorating due to oxidation, enzymatic hydrolysis, and microbes. Chemical synthetic preservatives are the most widely used preservatives in the food sector. Consumers have long been concerned about the safety of chemical preservatives due to the growing understanding of food safety as well as the possible hazards and unrecognized harms of chemical synthetic preservatives to human health. Contrarily, customers are becoming more and more interested in natural preservatives because of their positive antibacterial effects, environmentally friendly nature, and non-toxic qualities. The first part of this article discusses natural food preservatives, including those derived from various animals, plants, and microbes, as well as their uses in food. After that, the use and dose of the chemically produced preservatives were highlighted. Finally, to increase public knowledge of food safety, this article evaluates and summarizes the issues with current food preservatives.

Keywords: Food safety; natural preservatives; chemical synthesis anti-corrosion.

1. Introduction

Extending the ideal interval for eating has become crucial because of the growth of transportation and the food business, which has resulted in a longer time between food production and consumption. Physical, chemical, enzymatic, and microbiological dangers are the main causes of food spoiling, with microorganisms playing a major part in this. Food includes many nutrients, which creates an atmosphere that is ideal for the growth of microorganisms if they are in their ideal living conditions. Food deterioration will increase as germs continue to proliferate. Effective preservation techniques are required for food storage since consuming rotten or expired food unintentionally might result in food illness.

Anti-corrosion chemicals can increase the shelf life of food in addition to more conventional preservation techniques like chilling, freezing, salting, and drying. Food preservers are crucial food additives that can increase food shelf life, guarantee food quality, and stop food from spoiling. Preservatives can be classified as either natural or chemical depending on their makeup and source. Chemically created preservatives have strong anti-corrosion properties, may effectively stop food spoiling, and can prevent the development and reproduction of germs. They could, however, be subject to cumulative toxicity, teratogenicity, and other restrictions in their use. Natural preservatives are more frequently utilized and take on more significance than chemically created preservatives since they are derived from natural resources and offer effective, safe, and environmentally friendly anti-corrosion qualities. As a result, the focus of this article is on the introduction of both naturally occurring and chemically produced food preservatives, as well as an examination of their uses in food.

2. Natural food preservatives

2.1. Natural food preservatives from animal sources

Animal preservatives are physiologically active compounds with a preservation action that are chemically isolated from certain animal bodies or their metabolites. They mostly consist of antibacterial enzymes, antimicrobial peptides, and antioxidant peptides, according to functional categorization.

2.1.1 Antibacterial enzymes

Enzymes have a variety of methods through which they can behave antibacterially. For instance, lactoperoxidase (LPO) and other peroxidase systems have antibacterial effects through catalytic oxidation, and LPO inhibits the growth of both Gram-positive and negative bacteria. Lysozyme and other antibacterial enzymes primarily exhibit antibacterial activity by catalyzing the cleavage of cell surface polymers or cell walls, inducing bacterial decomposition. To stop food from spoiling and fruit from aging, lysozyme is frequently used to preserve meat, meat products, fish, and their products, milk, and dairy goods. Lysozyme has antibacterial action against a variety of bacteria and fungi, particularly Gram-positive bacteria, and when combined with other preservatives, this antibacterial activity can be increased. According to research, lysozyme and lactostreptococcin work together to kill Gram-positive bacteria. In food packaging, lactoperoxidase is a significant natural antibacterial agent that has bactericidal or antibacterial properties. Mohamed et al. directly added the lactate peroxidase system (LPOS) to chitosan membranes of various concentrations and discovered that, in comparison to the control group, the LPOS group significantly decreased the number of spoilage bacteria, fluorescent bacteria, psychrophilic bacteria, and neutrophilic bacteria during storage [1].

2.1.2 Antibacterial and antioxidant peptides

The term "antibacterial peptides" (AMPS) refers to oligopeptides with 20–60 amino acid residues that exhibit broad-spectrum antibacterial action against bacteria, fungi, protozoa, and certain viruses. They may be kept apart from other living things including plants, animals, insects, crustaceans, and marine life [2]. Mammals, amphibians, fish, and other animals are the principal sources of animal-derived antimicrobial peptides. Lactoferrin, protamine, and chitosan are a few possible animal-derived antibiotics. Protamine is a cationic antimicrobial peptide that binds to bacterial cell walls in a specific structure or form, inhibiting the formation of cell walls, inhibiting cell metabolism, and ultimately killing cells. Lactoferrin is an iron-binding protein with cationic properties that has antibacterial activity. It is primarily found in milk and other animal secretions. Fish, birds, and mammals all have sperm cells that contain protamine. Chitosan is primarily found in the exoskeletons of crustaceans and arthropods and has antibacterial activity against bacteria, fungi, and viruses. It is currently used primarily in foods like milk and bread and has antibacterial activity against bacteria and mold, especially against Gram-positive bacteria. Proteins and their hydrolysates, peptides, and amino acids are the primary types of antioxidant peptides. The antioxidant activity of peptides is mostly dependent on the binding properties of metal ions and free radicals. The amino acids in proteins' structural components and the active peptides produced during enzymatic hydrolysis are responsible for the antioxidant activity of proteins. When fish and chicken enzymatic hydrolysates were combined with beef mince, Centenaro et al. discovered that the enzymatic hydrolysates showed antioxidant properties that could stop beef lipid oxidation. Lipid oxidation was inhibited at rates of 93% and 80%, respectively [3].

2.2. Plant-derived natural food preservatives

The majority of plant preservatives come from plant extracts, including some natural herbs, spices, and essential oils. Plant extracts and essential oils have been used as food preservatives, spices, and medicinal remedies for a long time because of their distinctive flavors and antibacterial and anti-corrosion properties.

2.2.1 Plant extracts

The roots, stems, leaves, flowers, fruits, bark, and other parts of plants are frequently used to make plant extracts. The use of some extract concentrations should be limited since they have potent tastes and can be unpleasant to the senses in large doses. Plant extracts' bioactive phytochemical content undergoes both qualitative and quantitative changes that affect how effective they are. The microbial composition, flavor, and taste of food can all be impacted by these phytochemicals. Plant extracts have special antibacterial action because of their unique plant chemical makeup. Herb, spice, vegetable, and fruit plant extracts have antibacterial effects on bacteria, yeast, and mold. The

development of foodborne pathogens can be effectively controlled by plant extracts, according to research. Ibrahim et al. showed that guava-filtered juice strongly prevented the development of *Escherichia coli* O157: H7 and *Salmonella* when it was taken from fresh guava fruit [4]. Natural antioxidants found in large quantities in plant extracts are crucial for diet. Antioxidants are food additives that can prolong the shelf life of food by delaying or preventing food from being rancid as a result of oxidation. Numerous fruits and vegetables may be regarded as significant sources of natural antioxidants for bolstering and stabilizing food, and the majority of plant-based antioxidants demonstrate protective benefits comparable to butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT). According to research on the antioxidant properties of plant extracts in food, tomato, and garlic extracts can prevent lipid oxidation in pickled anchovy and frozen fish flesh. In their investigation of the impact of the plant extract Rosmol-P (RP) on the stability of mackerel during cryopreservation, Aubourg et al. discovered that the oxidation rate of the RP treatment was lower than that of the control group, particularly at higher doses. Rosemary's antioxidant activity is four times more than that of BHT and BHA. Plant-type antioxidants like rosemary have the power to break oxidative chains and stabilize free radicals. According to research, rosemary extract significantly reduces lipid oxidation in goldfish fillets [5].

2.2.2 Essential oils

The liquid known as an essential oil (EO) is fragrant and volatile and is made from natural herbs and spices. It contains a lot of secondary metabolites, which slow or prevent the growth of bacteria, yeast, and mold. Essential oils have been utilized for millennia in the food, drug, perfume, and cosmetics sectors as a component of spices or herbs. Essential oils are mostly utilized as seasonings in the food business. Antibacterial substances have reportedly been discovered in essential oils that have been derived from roots, leaves, flowers, buds, bulbs, seeds, fruits, or other sections of plants [6]. The chemical makeup of plant essential oils depends on a number of variables, including the type of plant, the season in which it is collected, the location of the harvest, and even the technique used to extract the essential oil. Herbal essential oils' antimicrobial properties are at their peak during or right after blooming. Some of the antibacterial substances in essential oils are found naturally in plants, while others are created by plants in response to microbial assaults or self-damage. The majority of essential oils stand out as a natural antibacterial agent in food preservation due to their sophisticated extraction technique, potent antibacterial impact, and non-toxic and safe nature.

2.3. Natural food preservatives from microbial sources

Numerous substances that bacteria make can be employed to stop possible spoiling or the development of harmful pathogens. Food-grade bacteria may produce a wide range of various compounds and stop other germs from growing. These food-grade microorganisms have a variety of biological preservation traits based on the kinds and forms of antibacterial substances (bacteriocins, enzymes, and other metabolites).

Microbial fermentation agents have been utilized for food fermentation to produce more stable goods for a very long time. Starter cultures and protective cultures are two categories of microbial cultures used in food production. Protective cultures may increase the safety of food microbes, whereas starter cultures improve the nutritional and sensory qualities of food. Lactic acid bacteria are frequently seen as suitable candidates because of their capacity to limit microbial development. The bacteriocins, organic acids, hydrogen peroxide, and diacetyl generated by lactic acid bacteria are its antibacterial components. Lactic acid bacteria (LAB) have been employed in the manufacturing of fermented foods for a long time to impart the preferred taste, flavor, and texture as well as to stop the growth of harmful germs. The prokaryotic bacterium *Streptococcus lactis* produces lactic acid streptococin, also known as Nisin, as part of its secondary metabolism. It is a biodegradable, non-toxic natural preservative with a broad antibacterial range. Early research has indicated that the heart. The majority of Gram-positive bacteria, *Clostridium botulinum*, *Staphylococcus aureus*, *Streptococcus hemolyticus*, heat-resistant spoilage bacteria, and other microbes that cause food spoiling may all be efficiently stopped from growing and reproducing [7]. The Ministry of Health

authorized the use of lactic acid streptococci as a food preservative in January 1990. According to research, it exhibits antibacterial properties on some Gram-negative bacteria when exposed to specific circumstances including freezing, heating, reducing pH, or surface activation with chelating agents like EDTA and citric acid. The consensus regarding the antibacterial mechanism of lactic acid streptococci is that it "adsorbs conjugates" on the cell membrane of Gram-negative bacteria through non-specific (positive and negative charge interaction), invades and destroys the cell membrane structure to form multi-permeable pores, changes in intracellular osmotic pressure, and inhibits cell autolysis after being added to the food system. In industries including meat, dairy, brewing, fish, vegetable processing, and food packaging films, lactic acid streptococci is employed. Through biological fermentation, the microbial food preservative natamycin was obtained from actinomycetes such as *Streptomyces natale*, *Streptomyces chattanuga*, and *Streptomyces fusarium*. While it has no inhibitory effect on bacteria and viruses, it can inhibit fungus, yeast, certain protozoa, and some types of algae. When natamycin interacts with sterol molecules on a fungal cell membrane, it can modify the shape of the cell membrane and even cause it to rupture, allowing cell contents to seep out and ultimately causing inactivation and death. Natamycin, however, is unable to stop the development of rotting microorganisms. Non-toxic, chemically stable, and challenging to dissolve in both water and oil, natamycin is a good antibiotic. The majority of natamycin in the human body is eliminated in the feces and does not build up inside the body [8].

Antibacterial substances known as bacteriocins are also referred to as biological preservatives or natural preservatives. Bacteriocins demonstrate antibacterial action against Gram-positive bacteria and have bactericidal or antibacterial effects [9]. Food spoilage microorganisms and foodborne pathogens, such as *Staphylococcus aureus*, *Listeria monocytogenes*, and botulinum toxin, are successfully combated by the bacteriocins generated by lactic acid bacteria. Inoculating foods with lactic acid bacteria is one way to apply bacteriocins. Another way is to add bacteriocins in pure or semi-purified form. The last way is to ferment items employing strains that create bacteriocins. Bacteriocins cannot guarantee total food safety if the strain that makes them is incompatible with other cultures needed for fermentation. The growth of bacteria that cause food deterioration or harmful microorganisms can be stopped by the synthesis of microorganisms and their metabolites. The formation of several compounds by food-grade microbes can prevent the development of other microorganisms, bringing microbial ecosystems into a state of natural equilibrium. Microorganisms that include LAB are thought to be suitable candidates since they can restrict microbial development. LAB is used to produce fermented foods to improve the taste, flavor, and texture of the meal as well as to stop the growth of harmful germs. Consuming LAB is safe. Bacteriocins, organic acids, hydrogen peroxide, carbon dioxide, and diacetyl are the primary antibacterial elements of LAB. Bacteriocins are natural or biological preservatives that are produced by LAB and other bacterial strains and are among them. They have effective bactericidal or antibacterial actions against Gram-positive bacteria as well as foodborne pathogenic microorganisms such as *Staphylococcus aureus*, *Listeria monocytogenes*, and *Botulinum toxin*. At lower pH levels, bacteriocins have higher antibacterial action. Bacteriocins can also be combined with other antibacterial substances to strengthen their capacity to render germs inactive.

3. Chemically synthesized preservatives

Chemically synthesized preservatives' characteristics and synthesis are a crucial part of food additives because they efficiently restrict the development and reproduction of microorganisms, prevent food deterioration, increase food shelf life, and have positive anti-corrosion effects. It is affordable, sturdy, and works well on foods like pastries, spices, and meals. It is extensively used and successfully inhibits the development and reproduction of germs. Benzoic acid and its salts, p-hydroxybenzoate esters, sorbic acid and its salts, and propionate salts are the four most often used chemically manufactured food preservatives.

3.1. Benzoic acids

Benzoic acid, commonly known as benzoic acid, is a scaly or needle-like crystal that is only moderately soluble in water. The sodium version of benzoic acid is mostly employed in manufacture due to its poor solubility. Because it can efficiently suppress mold and bacteria, benzoic acid is a vital acidic food preservative with several uses. Can goods, drinks, soy sauce, and vinegar are a few examples of items that can have small quantities of additives added. Because it is inexpensive and efficient in acidic meals, sodium benzoate is frequently employed in acidic foods. Additionally, it works well against bacteria, yeast, and mold. The flavor is sweet and astringent, and the pH level has a significant impact on the anti-corrosion action. The impact considerably lowers and the phenomenon of superimposed poisoning occurs when the pH value is higher than 4. Therefore, there is a tendency for progressive abolition even if it is still in use. Currently, several areas and nations have placed restrictions on its usage and manufacture. It is typically added to canned and non-carbonated beverages in amounts of 0.1% to 1%, and it is also used as a fungicide in the pharmaceutical sector [10].

3.2. p-Hydroxybenzoate

Nipagin ester, also known as hydroxybenzoate, has excellent anti-corrosion properties, high bactericidal capacity, and stability. It may also suppress the activity of microbial cells and stop the growth of germs. With a mass fraction usually less than 0.05%, it is commonly used to preserve foods including fat goods, dairy products, fish items, drinks, and chocolates [11].

3.3. Sorbic acid and its salts

A new kind of food preservative is sorbic acid and its salts. Sorbic acid is a colorless, needle-shaped crystalline or white powder that dissolves readily in ethanol but not in water. Because it may engage in human metabolism to become CO₂ and H₂O, it is a preservative with the lowest toxicity and can be utilized as a component of food [12]. As a result, it has gained market acceptance and is often used in the food processing sector, including in the production of fake cream, drinks, dried fruits, and canned vegetables, among other things. Despite having good solubility, potassium sorbate is expensive. Therefore, due to its low cost, strong water solubility, and ease of use, sodium sorbate offers a wide range of application prospects in the food business. In general, potassium sorbate can be used in a variety of ways, including direct addition, spraying on the food's surface, making it into a dry powder spray, immersion, and more. Generally speaking, different quantities of potassium sorbate are employed depending on the kind of food, such as 0.075 grams per kilogram for the preservation of meat, poultry, and eggs, and 0.2 grams per kilogram for the preservation of vegetables.

3.4. Propionate salts

Acidic preservatives called propionate salts have potent antibacterial properties in low pH medium. For instance, at pH 5.0 and pH 6.5, respectively, the minimal inhibitory concentration is 0.01% and 0.5%. When it comes to germs that make food stick, such as *Bacillus subtilis*, propionate salts work well. They have powerful antibacterial effects on molds, aerobic *Bacillus*, or Gram-negative bacteria. Aflatoxin synthesis is specifically prevented by them, whereas yeast is hardly affected at all. This property explains why propionate is frequently used to prevent mold in bread and pastries. Propionic acid is a typical dietary ingredient and a byproduct of the human metabolism. There are no toxicity concerns with propionate, hence ADI does not require any specific rules. In many items made from soy, such as bread, pastries, jelly, soy sauce, and vinegar, propionic acid has been utilized to inhibit mold growth. the meal listed above. Propionate (also known as propionic acid) can only be used up to 2.5g/kg at a time. A maximum of 3g/kg of sodium propionate is used in the manufacturing of cheese. The maximum amount of sodium propionate used in the production of bread and Western pastries is less than 2.5g/kg, and bread foaming is somewhat worse.

4. Summary

Food is a significant external source of nutrients and energy for people, and its cleanliness and safety are particularly crucial. Food preservation agents can stop food from going bad and increase its shelf life. As a result, food preservatives are crucial to the preservation and storage of food. Natural food preservatives are often created physically using metabolites from plants, animals, and microbes. They are safer, more environmentally friendly, and have potent antibacterial capabilities compared to artificial food preservatives. They also have no teratogenic or carcinogenic effects on humans. There are many different types of natural preservatives, however, they all have different antibacterial properties. It might occasionally be challenging to achieve the product's antibacterial standards when used alone. However, research on composite preservatives just began in recent years and has not been adequately supported by theory. Most natural preservatives still use traditional extraction and processing methods, which makes it difficult to produce in batches promptly and results in high production costs, which in turn results in a low enthusiasm for developing new natural food preservatives. Natural food additives generally have problems such as long research times, complex processes, and low extraction rates, which require a large amount of capital and human investment. Natural preservatives contain complicated chemical compositions and, depending on the dosage can be hazardous to human health. It might not satisfy the anti-corrosion criteria if added insufficiently. It might lower the product's quality if added excessively. Therefore, one of the main research directions in the field of food science at the moment is the creation of safe, dependable, affordable, and effective natural preservatives. This is also a crucial step in improving the productivity and security of the food business.

References

- [1] Mohamed C., et al. Antimicrobial and physical properties of edible chitosan films enhanced by lactoperoxidase system. *Food Hydrocolloids*, 2013, 30(2): 576-580.
- [2] Thibaut T., et al. Natural antifungal peptides/proteins as models for novel food preservatives. *Comprehensive Reviews in Food Science and Food Safety*, 2019, 18(5): 1327-1360.
- [3] Centenaro G S, et al. Fractionation of protein hydrolysates of fish and chicken using membrane ultrafiltration: investigation of antioxidant activity. *Applied Biochemistry and Biotechnology*, 2014, 172(6): 2877-2893.
- [4] Ibrahim S.A., et al. antimicrobial effect of guava on *Escherichiacoli* O157:H7 and *Salmonella* Typhimurium in liquid medium. *International Journal of Food Properties*, 2011, 14(1): 102-109.
- [5] Aubourg S., et al. Damage inhibition during frozen storage of horse mackerel (*Trachurus trachurus*) fillets by previous plant extract treatment. *Journal of Food Science*, 2010, 69(2): 136-141.
- [6] Srutee R., et al. Recent trends in the application of essential oils: The next generation of food preservation and food packaging. *Trends in Food Science & Technology*, 2022. 129: 421-439.
- [7] Simon K., et al. Conditions of nisin production by *Lactococcus lactis* subsp. *lactic* and its main uses as a food preservative. *Archives of Microbiology*, 2021, 203: 465-480.
- [8] Lee N.K., et al. Status, Antimicrobial Mechanism, and Regulation of Natural Preservatives in Livestock Food Systems. *Korean Journal for Food Science of Animal Resources*, 2016, 36.
- [9] Eldin M.J., et al. Bacteriocins as food preservatives: Challenges and emerging horizons. *Critical Reviews in Food Science and Nutrition*, 2018, 58(16): 2743-2767.
- [10] Elisabeth Maier, et al. Food preservatives sodium benzoate and propionic acid and colorant curcumin suppress Th1-type immune response in vitro. *Food and Chemical Toxicology*, 2010, 48(7): 1950-1956.
- [11] Zvonimir P., et al. The controversies of parabens - an overview nowadays, 2021, 71(1): 17-32.
- [12] Elena N.E., et al. Inhibition effect of food preservatives on endoproteinases. *Food Chemistry*, 2017, 235(15): 294-297.
- [13] Peter W.P. Resistance of yeasts to weak organic acid food preservatives. *Advances in Applied Microbiology*, 2011, 77: 97-113.