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# Potential of Bio-Preservatives to Enhance Food Safety and Shelf Life: Natural Preservation

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## ABSTRACT

Food safety is becoming a global concern, and the use of chemical preservatives has many negative impacts therefore, bio-preservatives have gained more interest. Bio-preservatives are important for improving food quality and safety. These compounds can be used in combination with other preservatives or alone to enhance product shelf life. These preservatives are mainly extracted and isolated as secondary metabolites of plants, animals, and microorganisms. Use of specific bio-preservatives should be according to the type of target organism. Bio-preservatives possibly can prevent microbial growth and hence maintain food safety and shelf life without compromising the organoleptic properties of food products.

**Keywords:** Bio-preservatives, Shelf life, Food Quality, Preservation, Antimicrobial

## Introduction

Sustainable approaches safeguard the health and well-being of people, animals, and the environment, with a strong focus on ensuring food safety. With time, people are demanding high-quality food products. Food safety is an important parameter during food handling and production as it reduces food-borne illnesses and ensures safe food products [1]. Over the past few decades, there has been an increased demand for natural food preservatives. Natural preservatives are considered safe for use and are mainly from animals, plants, and microorganisms known as bio-preservatives (figure 1) [2]. The utilization of bio-preservatives has been considered an efficient solution for problems related to food. Furthermore, bio-preservatives reduce the use of chemicals, salt, and sugar by using microorganisms or metabolic by-products of microorganisms. A variety of bio-preservatives have different mechanisms for different organisms present in food and can be applied to various foods including fruits, vegetables, seafood, dairy products, raw and processed food, and cereal products. The techniques of bio-preservation are not only economically acceptable, but these techniques also improve the nutritional and sensory characteristics of food, its stability, and safety as well [3].

Bio-preservation is the process of using non-pathogenic microorganisms or metabolites of non-pathogenic microorganisms to improve food safety and the shelf life of food products [4]. Fermentation is thought to be the most common and important type of bio-preservation. Microorganisms added externally or present naturally play a role in the destruction of complex food components and release organic acids, and alcohols. The process of fermentation produces taste and aroma compounds which in turn results in improved sensory properties of food products. The use of specific microorganisms for bio-preservation must be according to the type of food product because microorganisms or probiotic strains can cause off-flavors. The most commonly used bio-preservatives in industrial processes include lactic acid bacteria, bacteriocins, bacteriophages, and lysozymes [5].

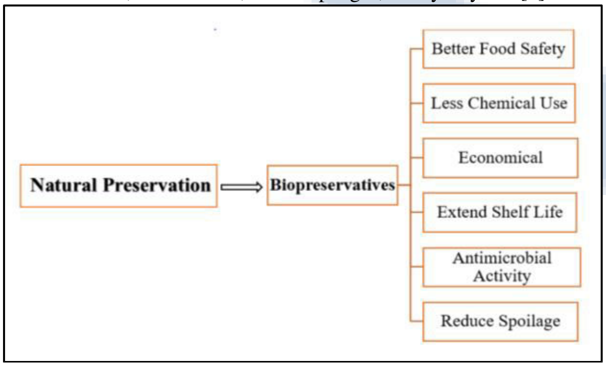


**Fig. 1.** Significance of bio-preservatives in Food

### Mechanism of Action of Bio-Preservatives

Bacteriocins possess an inhibitory mechanism (table 1) that prevents bacterial growth from penetrating the target cell, decreasing peptidoglycan production, and degrading the target cell's DNA by controlling protein synthesis through interaction with tRNA or ribosomes [6]. Pediocins are a category of bacteriocins that work actively against *Lactobacillus*, *Enterococcus*, *Streptococcus*, *Listeria*, *Carnobacterium*, and *Leuconostoc* and are utilized as bio-preservatives to preserve fruits, vegetables, and meat products. Bacteriocins that are obtained from gram-negative bacteria degrade DNA, RNA, and tRNase by pore formation in bacterial cell walls, and disrupt enzymatic reactions [7]. Bacteriophages inhibit the activity of *S.aureus* in curd, *Salmonella,* and *L.monocytogenes* activity in cheese, and *Enterobacter sakazakii* activity in infant milk [8]. Phenolic compounds having a hydroxyl group help in the inhibition of the target organism's activity. Essential oils can be added to food as a spray or directly which inhibits phosphorylation, protein translocation, enzymatic activities, and electron transport, and thus destroys target microorganisms [9].

Spices like cinnamon possess antibacterial effects against gram-positive and gram-negative bacteria which consist of *Bacillus cereus*, *L. monocytogenes*, *Escherichia coli*, *Salmonella anatum*, and *S. aureus* [10]. Bio-preservatives obtained from animals such as chitosan are found in the exoskeleton of arthropods and crustaceans. Chitosan is a polycationic biopolymer and a by-product of chitin that is industrially prepared from the processing of shellfish. It plays a role in inhibiting foodborne organisms like *Rhizopus stolonifera*, *Salmonella*, *Botrytis cinerea*, *Saccharomyces cerevisiae*, and *Aspergillus flavus* [11]. An enzyme called lactoperoxidase is found in animal secretions such as raw milk, saliva, and other secretions and possesses antimicrobial compounds. Lysozyme is found in insects, mammalian milk, avian eggs, and fish and these microorganisms tend to have preservative functions [12].

**Table 1.** Impact and mechanism of action of various bio-preservatives on food safety

| Bio-preservative | Mechanism of action | Beneficial effect on food | Reference |
|---|---|---|---|
| Enterocin | • Causes hydrolysis of the cell wall<br>• Inhibits the activity of negatively charged organisms<br>• Destroys membranes of target organisms | Inhibits the activity of<br>• *B. cereus* in yogurt and cheese<br>• *L. monocytogenes* in meat products<br>• *S. aureus*, *E. coli*, and *B. cereus* in fruits, vegetables, and rice | [13] |
| Chitosan | • Binds to the cell wall of negatively charged organisms<br>• Disrupts the cell wall and alters membrane permeability | • Foodborne yeast, mold, and bacterial growth is inhibited by chitosan | [14] |
| Lactoperoxidase | • Hydrogen peroxide and | • Preservation of infant | [15] |



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|---|---|---|---|
| | thiocyanate are involved in the initiation of oxidation reactions | formulas, eggs, ice cream, and cheese | |
| Lacticin | • Diminishes the activity of important enzymes present in target organisms | • Preserve and improve the shelf life of dairy products | [6, 7] |
| Nisin | • Destroys target organisms by forming pores and thus working as membrane permeabilizers | • Prevents pathogenic bacterial growth in canned foods<br>• Increases the shelf life of brined shrimps<br>• Acts as a natural preservative for soups, sauces, ripened and processed cheese, pasteurized liquid eggs, salads, and creams | [6] |

**Classification and Applications of Bio-preservatives**

Several animals, plants, and microorganisms possess anti-microbial properties, for such reason, they can be utilized as bio-preservatives to reduce unwanted physical and chemical changes in food products while assuring food safety [16].

**Plant-Derived Bio-preservatives**

Spices, herbs, fruits, and vegetables consist of a wide variety of active components having antifungal, antibacterial, antiviral, and antiparasitic properties. Plants are considered to have secondary metabolites containing alkaloids, terpenoids, tannins, oxygen-substituted derivatives, phenolic acids, terpenoids, aldehydes, and iso-flavonoids which inhibit harmful bacterial growth [17]. Extracts and essential oils obtained from plants have most widely been used as food additives to improve the shelf life and flavor of food products by controlling microbial activity. The antimicrobial activity of plant-derived compounds depends mainly on the type of microorganisms. It is reported that clove oil and cinnamon contain a range of active chemicals such as cinnamaldehyde, linalool, and eugenol. The combination of both oils helps in the reduction of the growth of molds and yeasts and when applied to dried fish, its shelf life is improved. Studies have shown that essential oil obtained from citrus peel helps improve the organoleptic properties of bread and also reduces microbial growth. Molds and germs are inhibited simply by spraying essential oil obtained from the peel [18].

**Animal-derived Bio-preservatives**

Antimicrobial peptides and proteins are a major part of the defense mechanism in amphibians, insects, and mammals. Some of the major bio-preservatives obtained from animals that can be greatly used in the food industry include protamine, defensins, pleurocidin, chitosan, and overtransferrin [19]. Bio-preservatives obtained from insects include lebocin, formaecin, attacin, heliomicin, coleoptericin, apidaecin, termicin, thanatin, ceratotoxin, diptericin, spinigerenin, drosocin, stomoxyn, defensin A, pyrrhocoricinitin, and metchnikowin. Chitosan is widely used in industries and is now utilized in films and edible coating to increase the shelf life of fruits and reduce spoilage [20]. Eggs and milk contain lysozyme which possesses antibacterial properties and is used to preserve chicken, fruits, and meat. Lysozyme can hydrolyze the connection between N-acetyl glucosamine and N-acetylmuramic acid and thus possess antibacterial properties. Lysozyme is commercially used in cheese to prevent *Clostridium tyrobutyricum*. Lactoferrin is another antimicrobial agent found in the secretion of mammals including milk, and saliva [18].

**Microbe Derived Bio-preservatives**

Bacteriophages which include siphoviridae myoviridae, antifungal compounds such as natamysin, bacteriocins such as reuterin nisin, lacticins, endolysin, pediocins are the major microorganisms that can work as bio-preservatives [21]. Microbes that prevent the growth of harmful organisms can be used as preservatives in foods. Bacteriocin can prevent microbial and spoilage pathogens and thus possess antibacterial characteristics. Bacteriocins inhibit the activity of foodborne pathogens including *L. monocytogenes*, *Clostridium botulinum*, and *Enterococcus faecalis,* and can be used as bio-preservative because it is protease-degradable. Lactic acid bacteria extend the shelf life of perishable food products, are probiotic, and possess antimicrobial properties [22]. Lactobacillus gives rise to reutericyclin and reuterin, both of which possess antimicrobial activity against gram-positive bacteria. Pediocin is another bacteriocin that is effective against *Lactobacillus*, *Clostridium*, *Enterococcus*, *Carnobacterium*, and *Streptococcus* species. Pediocin can be used as a preservative for meat products, and cheese [18].

**Conclusion**

In conclusion, there is an increased demand for natural preservatives due to food safety concerns because chemical preservatives tend to affect food negatively. From microorganisms, key compounds such as bacteriophages and bacteriocins are utilized. Plant-derived secondary metabolites, including terpenoids, alkaloids, phenolic acids, flavonoids, and essential oils, also serve as valuable bio-preservatives. Additionally, animal-origin substances like chitosan, lactoferrin, and lysozyme contribute to the effectiveness of bio-preservatives. Together, these diverse compounds play a crucial role in enhancing preservation and extending the shelf life of various products. Bio-preservatives can maintain food safety and shelf life without compromising the organoleptic properties of food products.

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