

Application of Natural Preservatives in the Seafood Industry

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Abstract

This article examines innovative natural preservatives derived from plants, bacteria, fungi, animals and algae and their application in seafood to ensure freshness and extend shelf life. Food preservative additives are natural or artificial compounds that prevent microbial growth, enzyme activity and oxidation without causing food deterioration. Synthetic food additives were more widely used in the past. Consumers do not accept synthetic additives because of several health concerns, so interest in natural preservatives is increasing. Seafood contains high moisture content and volatile compounds, so it can quickly spoil and change in native colour, texture and odour. After harvesting, fish require proper care to minimise quality loss. Recently, several advanced technologies have been used for preservation. Additives and preservatives are the best methods for fresh and processed seafood products. Natural additives help maintain the quality of fishery products with minimal effects on their native composition.

Introduction

Fresh fish spoils quickly because of its high moisture, nutrient content, weak connective tissue and neutral pH. Seafood quality depends on initial quality, catch time, catch location, species, gender, body composition, and handling conditions. Food spoilage is considered any change that makes the product unacceptable for human consumption. Spoilage of fish begins just after death due to autolytic activity, microbial activity and autoxidation. Therefore, fish require efficient techniques such as chilling, salting and freezing. Preservatives and additives are increasingly used to extend shelf life. A preservative is defined as a substance that helps prevent changes in food during transportation and storage.

Consumer demand is shifting toward nutritious, artificial-additive-free, ready-to-eat foods with long shelf lives. This pressure drives researchers to study alternative additives to produce safe, healthy food. The importance of natural preservative compounds is increasing because they are used more widely in food than synthetic compounds. Preservatives are divided into antimicrobials, antioxidants and anti-browning agents. Studies on the use of natural preservatives for fishery products have been conducted, and efforts continue to identify novel natural preservatives. Naturally preserving susceptible seafood products is essential to protect

public health and prevent losses. This chapter discusses novel natural preservatives of plant, animal and microbial origin and their application in fish and fishery products to maintain acceptability.

Food additives

Additives are not naturally found in the food system, but they are mixtures of substances used to maintain the overall sensory and organoleptic characteristics of foods during processing, such as production, packaging, and storage. Codex Alimentarius define the additive as 'any substance not commonly consumed as a food by itself and not generally used as a typical ingredient of the food, whether or not it has nutritive value, the intentional addition of which to food for a technological (including organoleptic) purpose in the manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food results, or maybe reasonably expected to result (directly or indirectly), in it or its by-products becoming a component of or otherwise affecting the characteristics of such foods. The term does not include contaminants or substances added to food to maintain or improve nutritional qualities. The use of food additives in the food industry stems from technological advances and changing consumer preferences. This has made it possible to reduce losses, improve quality, extend shelf life, create new formulations and standardised products. Food additives include preservatives, aroma and structural and nutritional protectors. They can be divided into preservatives, nutritional additives, colouring agents, flavouring agents, texturising agents and miscellaneous agents. Many additives are used in our regular life. Most preservatives serve several purposes, not just one and also address human health and safety. Several antimicrobials are used in foods, such as benzoates, sorbates, propionates and nitrites. However, Synthetic additives have potentially dangerous effects on health. Sodium benzoate is not harmful in the future, but this has not yet been proven.

While some researchers consider sodium sulfate dangerous to health, others disagree. Uncertainties and concerns remain about sodium sorbate. Antioxidants are additives that reduce or prevent oxidation-related food rancidity, thereby lengthening the product's shelf life. The food industry uses several types of antioxidants. Butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), ethoxyquin (TQ), tert-butylhydroquinone (TBHQ) and

propyl gallate are common synthetic antioxidants. BHA and BHT are phenolic antioxidants that stabilise free radicals by isolating them and preventing chain reactions. Because their chemical structures are highly volatile, they are not recommended for thermal methods such as baking or frying. Antioxidants can develop undesirable properties during high-temperature processes over extended periods. However, they can transfer from feed to farmed animals and be consumed by humans.

Because synthetic preservatives can cause specific health problems, replacing them with natural preservatives is safer for humans and the environment. These concerns about artificial preservatives have increased attention to natural preservatives. Natural preservatives can come from different sources, such as plants, bacteria, fungi, animals and algae.

thyme and oregano; carvacrol from oregano; and anethole from anise.

Preservatives are commonly used to decrease the risk of foodborne sickness. Herbs and spices are alternative sources of novel antimicrobial compounds, although most are isolated from bacteria and fungi.

Plant extracts

Plant extracts are usually obtained from various plant parts such as leaves, stems, flowers, fruits, roots, and bark. Plants contain chemicals called phytochemicals that affect foods' microbial, chemical and sensory qualities. Qualitative and quantitative variations in bioactive phytochemical content in plant extracts result in variable effectiveness. These phytochemicals are categorised as polyphenols, flavonoids, tannins, alkaloids, terpenoids, isothiocyanates, lectins and polypeptides. Plant extracts have long been used in the food industry as seasonings because of their unique flavours.

However, some extracts have a strong flavour which limits their use because high concentrations may cause undesirable sensory properties. Therefore, extract levels should be kept low in foods. Combinations of various plant extracts, used for their antimicrobial efficiency at low concentrations, are always recommended. Combined plant extracts have been reported to be more effective than individual use. Most of the extracts are soluble. They can be extracted from plant materials using different solvents, such as aqueous, alcohol, lipid or supercritical carbon dioxide. Researchers extract and purify active compounds using other methods. The purity and quality of plant extracts depend on the extraction method. Most extraction methods are time-consuming and troublesome and require large quantities of other solvents, some of which are toxic. Common solvent- or temperature-based extraction methods can reduce the content, purity, activity and characteristics of different plant components. Direct extraction extracts compounds with minimal processing and prevents alteration of active compounds. This method is easy, simple, and fast, and it does not require a chemical solvent or technology. Direct extraction involves collecting the liquid part of the natural material and using it directly. This method has been shown to effectively control foodborne pathogen growth.

Table 1. List of plant-based extract Preservatives Anti-microbial agents

Plant source	Important compounds	Main action in seafood
Rosemary	Rosmarinic acid, carnosic acid	Antioxidant, antimicrobial

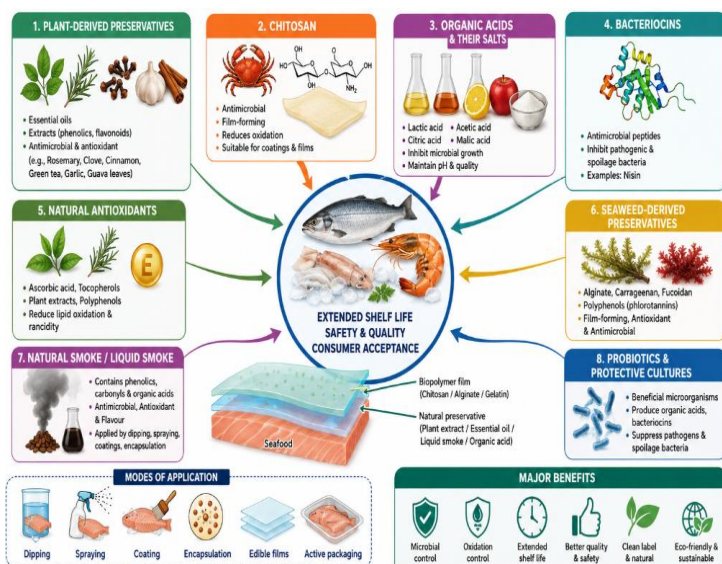


Figure 1. Applications of natural preservatives to enhance or maintain the quality and safety of seafood

Plant-based preservatives

Natural herbs and spices can potentially substitute for artificial preservatives and their preservative activity depends on the type, nature and concentration of the organism. Herbs and spices contain various volatile chemicals. Different methods extract these chemicals for preservative production. The compounds in herbs and spices protect the plant against infectious organisms as a self-defence mechanism. Plant oils and extracts have been used as food preservatives and medical therapeutic agents. Many cultures in India, North America and China have used various herbs and spices as flavourings and food preservatives since ancient times. Different phenolic compounds are the main antimicrobial components in plants, their extracts and essential oils (EOs), such as cinnamic aldehyde from cinnamon; eugenol from clove and cinnamon; thymol from

Oregano	Carvacrol, thymol	Strong antimicrobial activity
Thyme	Thymol, carvacrol	Antimicrobial and antioxidant
Clove	Eugenol	Antimicrobial, antioxidant
Cinnamon	Cinnamaldehyde	Antimicrobial and antioxidant
Garlic	Allicin	Antimicrobial
Ginger	Gingerols, shogaols	Antioxidant and antimicrobial
Turmeric	Curcumin	Antioxidant and antimicrobial
Green tea	Catechins, EGCG	Antioxidant and antimicrobial
Grape seed	Proanthocyanidins	Strong antioxidant
Pomegranate	Ellagitannins, phenolic compounds	Antioxidant and antimicrobial
Citrus fruits	Flavonoids, citric acid, essential oils	Antioxidant and antimicrobial

Plant extracts have antimicrobial activity due to their phytochemical components. Various plant extracts have antimicrobial activity against bacteria, yeast, and mould and can also increase storage stability due to active compounds, including phenols, alcohols, aldehydes, ketones, ethers, and hydrocarbons. Researchers have reported antimicrobial effects of plant extracts derived from herbs, spices, vegetables and fruits. Many researchers have investigated the antimicrobial effects of plant extracts on seafood. Effects of grapefruit seed extract and lemon extract against the main fish spoilage microorganisms (*Pseudomonas fluorescens*, *Photobacterium phosphoreum* and *Shewanella putrefaciens*) were investigated in fish hamburgers. Application of these extracts increased the microbial stability limit. Commercial extracts of garlic, clove, tomato and grape seed were separately added to the batter-coating formulation, and quality changes were investigated during frozen storage. The results showed that plant extracts in the coating mixture affected shrimp quality during frozen storage.

Antioxidant agents

Natural antioxidants have been recognised to exhibit crucial roles in vivo and in foods. Different vegetables and fruits are promising sources of functional additives for food fortification and stabilisation because of their antioxidant properties. Plants are rich sources of natural antioxidant compounds. Plant-based antioxidants mostly show a protective effect similar to BHT and BHA. Phenolic

compounds commonly found in plants have various biological activities, including antioxidant properties. Herbs and spices such as oregano, rosemary, thyme, sage, basil, turmeric, ginger, garlic, nutmeg, clove, mace, savoury and fennel have been successfully used alone or in combination with other preservation methods. Some researchers have investigated the antioxidant effects of plant extracts in seafood.

Animal-based preservatives

Bioactive compounds derived from animal secretions or defence systems are used as food preservatives. Animals are rich sources of bioactive compounds. These bioactive compounds can affect human health when consumed through animal-based food products.

Table 2. List of Animal-based preservatives

Animal source	Preservative	Main function
Shrimp, crab, lobster shells	Chitosan	Antimicrobial, antioxidant, edible coating
Milk	Lactoferrin	Antimicrobial
Milk	Lactoperoxidase	Antimicrobial
Egg white	Lysozyme	Antibacterial
Eggs	Avidin	Antimicrobial by binding biotin
Fish skin, scales, bones	Gelatin	Film/coating formation; carrier for antimicrobials
Animal tissues	Collagen	Edible coating and protective film
Milk	Casein/caseinates	Film formation and protection against oxidation
Animal-derived peptides	Bioactive peptides	Antimicrobial and antioxidant activity

Antimicrobial enzymes

Enzymes may exert antibacterial activity through several mechanisms. Lysozymes and other antimicrobial enzymes primarily act by inducing bacteriolysis through catalytic cleavage of cell-surface polymers or cell-wall junctions. Lactoperoxidase and other peroxidase systems act antimicrobially via oxidative catalysis, producing toxic or inactivating products when suitable substrates are present. Lysozyme is a natural preservative with antimicrobial activity, especially against Gram-positive bacteria. This enzyme is widely used as a preservative for meat, meat products, fish and their products, milk and dairy products, and fruit and vegetables. Lysozyme has been shown to protect meat and fish

products. Lysozyme shows antimicrobial activity against a limited spectrum of microorganisms. Nisin and lysozyme have shown synergy against Gram-positive bacteria.

Antioxidant peptides

Antimicrobial peptides (AMPs) are oligopeptides composed of varying numbers of amino acids. They are small biological molecules with broad-spectrum activity against bacteria, fungi, protozoa and some viruses. Researchers first reported AMPs in the 1950s. During that period, researchers also isolated nisin as a food preservative from LAB. Subsequently, researchers isolated AMPs from other natural sources, including plants, insects, amphibians, crustaceans, and marine organisms. Animal-based AMPs are obtained from mammals, amphibians and fish. Potential antimicrobials of animal origin include lysozyme, lactoferrin, ovotransferrin, leukocidin, defensins, chitosan, etc. Lysozyme from different sources is commercialised as a natural preservative for food applications.

Microorganisms and their metabolite-based preservatives

Bacteria produce many compounds that can prevent spoilage or the growth of pathogenic microorganisms. Food-grade microorganisms can form many different substances that inhibit other microorganisms. This results from the natural balance of the microbial ecosystem. The biopreservation features of these food-grade microorganisms vary by antimicrobial compound (bacteriocins, bacteriophages, enzymes, and other metabolites) and by compound form (purified compound, fermentate, protective culture).

Conclusions

Today's consumers prefer natural preservatives over synthetic additives, prompting food researchers and the industry to seek new, more effective natural solutions. Many undiscovered herbal, animal, or microbial ingredients likely remain beyond the current options. Further studies are necessary to identify new natural preservatives, understand their active components and evaluate their protective effects on foods. Additionally, researchers must determine optimal concentrations for food applications. Seafood, vital for human nutrition and highly prone to spoilage, particularly benefits from such preservation. Natural preservatives can extend seafood's shelf life, safeguard health, and reduce malnutrition and food waste.

References

- Branby-Smith FM, Bacteriocins: applications in food preservations. *Trends Food Sci Technol* 3:133-137 (1992).
- Carocho M, Barreiro MF, Morales P and Ferreira ICFR, Adding molecules to food, pros and cons: a review of synthetic and natural food additives. *Compr Rev Food Sci Food Saf* 13:377-399 (2014).
- Carocho M, Morales P and Ferreira ICFR, Natural food additives: Quo vadis? *Trends Food Sci Technol* 45:284-295 (2015).
- Gokoglu N, Yerlikaya P, Topuz OK and Buyukbenli HA, Effects of plant extracts on lipid oxidation in fish croquette during frozen storage. *Food Sci Biotechnol* 21:1641-1645 (2012).
- Hsieh PC, Mau JL and Huang SH, Antimicrobial effect of various combinations of plant extracts. *Food Microbiol* 18:35-43 (2001).
- Lin CC and Lin CS, Enhancement of the storage quality of frozen bonito fillets by glazing with tea extracts. *Food Control* 16:169-175 (2005).
- Ojagh SM, Sahar MA and Rezaei M, Effect of natural antioxidants on quality of common kilka (*Clupeonellacultriventriscaspia*) during storage with ice. *J Mar Sci Technol* 3:1-7 (2005).
- Pezeshk S, Ojagh SN and Alishahi A, Effect of plant antioxidant and antimicrobial compounds on the shelf-life of seafood-a review. *Czech J Food Sci* 33:195-203 (2015).
- Rohlik BA, Pipek P and Pánek J, The effect of natural antioxidants on the colour of dried/cooked sausages. *Czech J Food Sci* 28:249-257 (2010).
- Rassem HHA, Nour AH and Yunus RM, Techniques for extraction of essential oils from plants: a review. *Aust J Basic Appl Sci* 10:117-127 (2016).
- Saeed M, Khan WA, Shabbir MA, Khan MI, Randhawa MA and Yasmin I, Bacteriocins as a natural antimicrobial agent in food preservation: a review. *Pak J Food Sci* 24:244-255 (2014).
- WHO/FAO, World Health Organization/Food and Agriculture Organization of the United Nations, Codex Alimentarius Commission Procedural Manual, 14th edn.
