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Review Paper

Preservatives in food: Enhancing Shelf-life, Safety and Sustainability

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ABSTRACT

Natural food preservatives are extremely important for improving food safety and shelf-life. As a result, the purpose of this study was to analyze the literature on the possibility of using natural preservatives to improve food safety and increase product shelf life. According to the review study, natural antimicrobial compounds that suppress the development of bacteria and fungi in order to improve quality and extend shelf life have received a lot of attention in recent years. Natural antimicrobials are mostly harvested and separated as secondary metabolites from plants, animals, and microbes. Plants, particularly herbs and spices, are receiving increased attention as sources of natural antimicrobials. The food business extensively uses artificial preservatives to prevent deterioration caused by microbial multiplication, enzymatic activities, and oxidative reactions. This review focuses on the food preservatives studied in seafood matrices, their modes of application, concentrations commonly used, mechanisms of action, factors that interfere with their use, and the synergistic effect of the interactions among the naturally occurring preservatives, with a focus on maintaining quality and ensuring food safety.

INTRODUCTION

Food is essential to human existence. Food has been kept since ancient times, and all food used today aside from our own garden plants contains preservatives, which are chemicals added to food to prevent microbes from causing degradation. As a result, microorganisms like fungi and bacteria will be unable to proliferate. Food preservatives are necessary these days because food transportation depends on them. By doing this, you can stop the food from going bad for too long. Preservatives are usually present in packaged food because without them, the food would not last. Radioactive elements and cobalt-30 are examples of food preservatives. One example of current packaging technology is the preservation technique of vacuum and hypobaric packaging. [1] Food preservatives are additives that extend the life span of food while preserving its flavour and fragrance. The perennial tree of olives it develops

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in the Mediterranean region's moderate climate yields the fruit that is used to make olive oil. The age of the crop at collection and the cultivars influences the amount of phenolic substances in olives and their oil. A multi-step technique is commonly used to extract the oil from olives. Crushing the entire olive, including the pits, is the first step. Next, the paste is mixed, the oil that runs easily is collected, any remaining oil in the grinds is separated and collected under pressure, and finally the vegetation water and particles are separated from the olive oil. Virgin olive oil normally has an oleic acid content of no more than 2%, which is a measure of free acidity, in the presence of additional traits similar to the ones listed in the requirement for this group. Since olive phenols have potent antioxidant qualities, numerous scientists have tried to extract them from plant water; nevertheless, since the whole olive is macerated, some undesirable elements from the crushed pits are still present in the vegetation water. Microbially fermented teas have become more popular in the West recently, partly because of trade expansions between China and the West and a number of health benefits associated with microbial fermentation. [2] The creative trend of biological food preservation by using natural antibacterial agents has gained more attention in recent years. Research on the fungitoxicity of several angiosperm essential oils (EOs) focuses on a flavus (Navjot 4NSt), a potent post-harvest storage fungus that breaks down cereals and pulses. For the purpose of producing the necessary antimicrobial effects against molds and yeasts, one family of antimicrobial substances that can be used alone as well as in conjunction is alkyl esters of paraben (PABA). It is widely accepted that the primary mechanism by which these chemicals function is the suppression of transportation through membranes and the activity of mitochondria steps, although they may produce a wide range of physiological effects. Its low toxicity, stability over extended periods, and relative absence of irritation and sensitization make them safe for usage. For example, parabens are relatively not bothersome, non-sensitizing, and have little hazard. They also exhibit stability throughout an extensive pH spectrum and are adequately dissolve in liquids to provide a sufficient amount in the liquid state, which makes them an ideal preservative. [3] Paraben's antibacterial properties grow with the length of the ester group; however, the lower esters (methyl and propyl) lose some of their potency when the solubility of the ester group increases. The most apparent options for usage in food are propyl and methyl. For more than 50 years, methyl and propyl parabens have been used to keep bacteria out of food, medicine, and cosmetics. The Food and Drug Administration, FEMA, FAO/WHO, and other authorities have already finished their safety evaluations of this chemical. Humans have unintentionally utilized lactic acid bacteria (LAB), a broad group of helpful microbes, for thousands of years. They have been used as starting cultures to produce a wide range of fermented dairy products, including as yoghurt, cheese, buttermilk, kefir, and several things native to various nations. The Laboratory has been divided into multiple genera, including Enterococcus, Lactobacillus, Pedi coccus, Leucon Stoc, and Streptococcus, some of which are important for Lactococcus food. One genus that stands out among the others is Enterococcus. Enterococcus species come in many varieties in food products. It is thought that the earliest places they were thought to have appeared were in storage tanks, milking equipment, water, and animal excrement. From then, they are most frequently discovered in a variety of classic European cheeses that are mainly manufactured with raw goat or ewe's milk. Because of their capacity to degrade citrate, lipolyse, and go through proteolysis, these bacteria are now essential to the ripening process of these cheeses,

contributing to their unique flavor and aroma. Enterococci not only add a unique flavor and scent to food, but they also act as protective barriers against a variety of illnesses, such as Listeria monocytogenes, a common pathogen found in meat and dairy.[4]

1.1. Food safety:

Preventing foodborne illnesses brought on by eating tainted food is known as food safety. Food safety has drawn more attention from the industry due to different legal obligations, in addition to the fact that it (or information connected to it) can be an advantage in competition and, more crucially, since a serious food security incident can have detrimental repercussions on business. This covers product recalls, reputational harm, and responsibility damages for derogatory remarks.[5] Salmonella contamination led to a recent American peanut butter recall, which is a common instance of a dietary security problem. With over 200 food firms affected downwards in the distribution network and over 2100 products recalled overall, it was the biggest recall of goods in American history. Studies reveal that there are a large number of smaller-scale recalls in addition to the well-known large recalls, some of which are still resulting in fatalities or serious illnesses. [6]

Many guidelines and standards related to food safety have been created in the last few decades. The most well-known ones include the Hazard Analysis Critical Control Point (HACCP) system (FAO, 2003), the ISO 22000 standard (ISO, 2005), and the British BRC standards (British Retail Consortium, 2004). Systems like HACCP are built to control food safety by addressing a range of physical, chemical, and biological risks. They are based on concepts from risk management. [7] A HACCP technique's primary goal is provide a methodical way of identifying and minimizing threats to food safety. Standards like ISO 22000 and BRC, which offer a management framework for integrating food safety inside a company, typically incorporate HACCP. While HACCP development is becoming more and more common in large food enterprises, smaller businesses especially those in the foodservice industry—rarely employ it.[8] However, it must be mentioned that efforts have recently been made to address this issue by creating a special kind of food safety management system designed specifically for the foodservice industry. Governments are also enforcing regulations mandating that food products be traceable at every point of production, processing, and distribution.[9] While complete traceability is desirable, it is actually more of an aberration in the highly interconnected food supply chains. In actuality, complete traceability is less of an expectation and more of an exception. [10]

1.2. Sustainability:

In recent years, the food business has paid greater attention to sustainability. Sustainability is frequently used to describe meeting current demands without jeopardizing future generations' ability to meet their own needs. [11] That is becoming increasingly clear that market and regulatory sustainability factors influence supplier chains. Food distribution networks are setting the benchmark for this development. This includes topics like animal welfare, ethical raw material sourcing processes, and worker health and safety. Fair trade initiatives, for example, have been devised to improve the situation of food producers in poor nations.[12] Retailers and suppliers have a significant impact not just on distribution and temperature control, which are directly related to sustainability, but also on sourcing sustainable products from food manufacturers. These effects also include restaurant operations during preparation and service, waste, and refrigeration associated to storage.[13] Another well-known topic regarding the origin and sustainability of food chains is the concept of labeling, like dietary miles, which indicate the length of time an edible

item went to reach the consumer. Even though it only accounts for a small portion of the production and distribution system's overall environmental impact or carbon footprint, the idea has gained some popularity. [14] A product's assessment may also be influenced by whether it is "in season," as this can have a substantial impact on how much energy is used while it is stored. This natural side of stability has possible received the greatest importance. An instance is the life cycle assessment which is a method of analysis that assesses the ecological impact of a good through production to consuming. When assessing sustainability, keep in mind that the entire supply chain must be considered. Local product benefits in terms of nutrient mileage may be lost during a stage of manufacturing or preservation with higher environmental costs. [15] Even if items are utilized to mitigate the negative effects of commodities, greater consistency is required to better comparison studies and expand usage within the food industry. This is because each of these evaluations is fairly thorough. Numerous firms are beginning to pay attention to these issues under the umbrella of "Corporate Social Responsibility," or CSR.[16] They frequently publish updates on their corporate social responsibility results with customers, including as clients and workers. For example, while the United Kingdom's top ten merchants collectively declared that corporate social responsibility is an important part of their workplace, there are considerable variances in the type and amount of CSR data that they give. [17] But new studies have provided some guidance on how to approach this from a number of angles. In order to finally combine these three dimensions, current research has provided some advice on how to achieve this utilizing a number of ways. Furthermore, there are some developments being made toward a "social LCA," which aims to supplement the existing LCA methodologies and, in doing so, get closer to a methodology that would consider all facets of sustainability (see, for instance, to Promoting social and environmental consciousness can occasionally save a business money in addition to improving its reputation, like when food waste is reduced. [18]

1.3. Using plant antimicrobials to extend food's shelf life: to increase food's sustainability Antimicrobials derived from plants, or phytochemicals, are vital to a plant's proper functioning. These antimicrobial compounds are employed by the plants as a defensive mechanism to ward off plant diseases and other pests. It also regulates growth, pollination, and fertilization all of which increase soil fertility.[19] Plant phytochemicals can be broadly categorized into phenolic compounds, polypeptides, lectins, alkaloids, terpenoids, and essential oils. In addition to improving food's sensory attributes, they also have antibacterial and antioxidant properties, which prolong food's shelf life.[20]. Consuming meals high in polyphenols has been associated with positive health effects due to the biological properties and antioxidants present in phenolic compounds. [21] In short, antimicrobials are substances or chemical agents that, when introduced into a food matrix, having a capability to prevent or slow the progress of microorganisms. Antimicrobials are classified as "naturals," a group that encompasses both novel and traditional compounds. Natural antimicrobials come from microbiologically derived vegetable, fruit, herb, or spice source materials. One example of a product that can provide advantages such as antioxidants, natural antimicrobials that increase shelf life, and interesting new flavors is plant extracts. Let's discuss how these antimicrobial substances are used in the food industry to preserve food and extend its shelf life. [22]

1.4. Food Preservatives:

Foodstuffs, pharmaceuticals, artwork, organic samples, wood, and other items are treated with a natural or synthetic substance known as a

preservative to prevent microbial growth or unwanted chemical changes. Preservatives are classified under two groups based on their type. Natural preservatives such as wood smoke, honey, and salt fall within the Class 1 category. Class 2 preservatives are synthetic compounds. Eats Preservatives may be utilized either alone or as a combination with different preservative. Added nutrients are frequently included in meals to keep it fresh, preserve its nutritional content, or avoid deterioration. The primary purpose of these additions is to kill germs and prevent their proliferation. Consuming an excessive amount of salt can help with this. Salt consumption or dilution prevents food-degrading bacteria from developing. Antimicrobial preservation agents, which limit the expansion of fungal and bacterial organisms, are one form of preservative. Antioxidants, such as oxygen absorbers, prevent nutrients from mixing together. Calcium propionate, sulfur dioxide, potassium hydrogen sulfite, sodium bisulfite, and sodium nitrite are among the most common antimicrobial preservatives used. Another common preservative is disodium EDTA. Advantages and security of various artificial nutritional products. Traditionally, preservatives have been made from natural substances including sugar, salt, vinegar, and alcohol. Salt has been dried and smoked for food preservation since the beginning of time. Additionally, food can be preserved via techniques like freezing and dehydration. The enzymes in fruits and vegetables that continue to degrade even after they have been removed are the target of a separate class of preservatives. As an example, the citrus or ascorbic acids in lemons and other juices made from citrus can inhibit the enzyme known as phenolase, which browns cut apples and potato. Because they contain natural enzymes or compounds like alcohol or acids, many foods lose their therapeutic properties shortly after harvesting or processing. Conventional conservation approaches typically seek to remove air and bacteria, or to create an atmosphere that is harmful to living creatures and can cause degradation. Sugar and salt (NaCl) were two of the first preservatives known to man. Due to the high osmotic concentrations produced by these two substances, microorganisms were unable to proliferate and develop in the moist environment. Storage is used to help preserve jams and jellies due to their high sugar content.

2. Food Preservatives Types:

There are three categories of food preservatives: microbial, artificial, and natural.

2.1. Natural Preservatives:

Plant-based preservatives are healthy for humans. These are not harmful to our wellness. Natural means of preservation include salt, sugar, the vinegar, and rosemary extract. Pickling, boiling, freezing, and drying are popular kitchen preservation processes. Using natural food preservatives is quite safe. Naturally preservatives for food are frequently sourced from plants, animals, or microbial sources. The primary goal of natural stabilizers within the food sector is to inhibit the growth of unwanted microbes. Plant antimicrobials can be applied to food surfaces,[23] mixed into product formulations, and used in packaging materials. Furthermore, its manner of action is also unique. Many food firms have used enzymes from animals, microbial bactericides, Acids made from organic materials, organic polymers (Chitosan coating), and plant-derived oily substances.[24]. This is critical to encourage and understand the present level of knowledge about the possibility benefits of natural preservation for enhancing the safety of food and shelf lifespan of fresh, lightly processed, as well as readily consumable foods in to improve further study actions and address the problem of nutrition and food insecurity. nevertheless the chances for natural preservation have received little systematic studies. In specifically, the use of natural coatings

that are edible, the elements that influence natural goods' antimicrobial characteristics in order to enhance the security of food and preservation times, and the antioxidant and antibacterial properties of plants and animals. Thus, accumulating knowledge on the possibility and function of natural food preservatives in increasing food safety and its shelf life.[25] Natural preservatives have the potential to improve food safety and shelf life. Conventional food preservation procedures fail to prevent the transmission of meal-borne pathogens in food items. The increased customer desire for free of chemicals food has prompted the food sector to use antimicrobials. Antimicrobials is modern innovations that the food sector uses to improve the shelf life of food while also addressing safety and quality concerns.[2

Figure 1: The 25 selected antimicrobial spices recommended as natural food preservatives. [32]

a). Potentials of Natural Preservatives to Boost the Safety and Shelf Life of Foods:

Utilizing Antimicrobials Derived from Plants, Natural Preservatives Have the Potential to Increase Food Safety and Shelf Life. Raw fruits and vegetables, as well as herbs and spices, contain significant amounts of natural antibacterial compounds. Fruits and vegetables: garlic, spice, the onion, the cabbage, and the guava; seeds and leaves: olive leaves, the herb parsley, caraway seeds, nutmeg and fennel, and grape seeds; herbs and spices: marigold, basil, the herb, rosemary, thyme, Sage, cloves, and cardamom. are among the foods that naturally contain compounds derived from plants. Food additives, such plant-based extracts and essential oils (Eos), They have historically been utilized to enhance flavor and increase shelf life by inhibiting microbiological infection and preventing rancidification. In reality, these substances can inhibit or as reduce the development of harmful microbes due to their substantial amount of additional metabolite such as phenolic substances, iso-flavonoids, volatile oils, ketone bodies, aliphatic in alcohols, acidic substances, and aldehydes. The variety for bacteria, their size, the culture medium, the extraction method, and the antimicrobial activity assessment technique are the primary factors influencing the antimicrobial efficacy of derived from plants substances. Plant-derived compounds such as alkaloid compounds, volatile oils, and polyphenols are created naturally. Many of their secondary compounds are herbivore repellents or biocidal against bacteria, thus they defend plants from microbial infections and predators. The phenolic and polyphenolic families are two major kinds of secondary metabolite chemicals. Subgroup chemicals such as flavonoids, quinones, coumarins, phenolic acids, tannins, the form of phenol flavones or flavanols play essential roles in antimicrobial action. Phenol is a chemical that has a hydroxyl (-OH) group. The material's phenol group positions and content correspond to its microbiological toxicity it is associated with.[27]

b). Natural Fish Preservatives:

Using Natural Fish Preservatives to Extend Fish's Shelf-Life Fish that is fresh has a limited shelf life. It may be frozen or refrigerated, However, these techniques could not be adequate to avoid rancidity, oxidation of lipids, or growth of bacteria. Fish quality enhancement usually is always required. [28] For this reason, when storing fish, the right preservatives must be used. The rapid growth of the social economy has raised public awareness of the usage of natural preservatives in food. While consumers generally prefer foods free of preservatives, they will choose foods with natural preservatives over those with artificial ones if they are not available.[29] Foods with natural preservatives ensure that the meal is safe to eat and free of microorganisms. The best characteristics for natural preservatives are wide bactericide or fungicide actions, low-toxicity, activity at small amounts, no food flavoring or coloring, no medicinal uses label-friendliness, and expensive effectiveness. Preservatives that are natural are generally derived by three distinct sources: animals, plants, & microbes. Moreover, a variety of bioactive compounds obtained from algal cells, mushrooms, and various other sources could provide the food industry with novel natural preservatives.[30]. Certain types of lactic acid bacteria produce a variety of chemicals, such as hydroxyphenyl-lactate, propionate, bacteriocins, retrocyclin, diacetyl, and phenyl-lactate. They have antibacterial qualities when employed against microorganisms that cause fish to spoil while it is being stored and against diseases spread by food.

2.2. Artificial Preservatives:

Artificial preservatives are substances that stop microorganisms from growing and functioning in food, enabling it to be stored for long periods of time without losing its original nutrients. Among them are antibacterial and antioxidant substances. Antimicrobial agents are applied to stop microorganisms from acting. Antimicrobial agents include calcium propionate, sodium benzoates, sorbates, nitrites, EDTA, and benzoates. Antioxidants are compounds that prevent food components from oxidizing. Antioxidants with antibacterial properties include formaldehyde, ethanol, BHT, and BHA. These compounds can be used against food-borne diseases and spoilage bacteria in fish during storage.[31]

2.3. Microbial Preservatives:

Microbial preservatives are anti-oxidants that prevent food ingredients from oxidizing, similar to oxygen absorbers, or preservatives that stop the growth of bacteria and fungus.

2.4. Chemical Preservatives: class 1 and class 2:

Class 1 Preservatives include things like vinegar, glucose, honey, spices, sugar, vegetable oils, and salt. **Class 2** Preservatives include sodium benzoate, nitrites, and benzoic acid.

1.Sodium benzoate: Its primary application is as a preservative for food in the food manufacturing industry. The majority of it is created during the process of neutralizing of the acid benzoic. The sodium benzoate compound can be used at concentrations up to 0.1%. Its most common applications include food that is acidic, cosmetics, and pharmaceuticals.

2. Titanium dioxide: This nanoparticle is also known as nano titanium oxide. This is an odorless, crystallized, fine, lower-solubility a powder with a low toxicity. It helps maintain products and increases the lifespan of it. It's utilized in colors, dye, sunscreen, beauty products, paper goods, as well as printmaking.

3. Sodium chloride: Sodium chloride is a popular food preservative since it is affordable and harmless. Nacl is supposed to work well. [32]

Chemical preservatives:

A type of preservative that extends the lifespan of food by decreasing its water action, which prevents germ growth. "Preservatives" are compounds that can inhibit, halt, or eliminate the growth of germs or any other possible harm caused

by the existence of them. Preservatives used in foods increase the duration of storage of a variety of food items. By postponing the process of microbial degradation, preservatives aid in the preservation of food's color, texture, and flavor. Food preservatives come in two varieties: artificial and natural. Food can be preserved by a variety of substances that are present in plants, animals, and microbes. They also function as antioxidants, flavorings, and antimicrobials. a few naturally occurring compounds and how they are used to preserve food. Artificial preservatives are made by industrial procedures. These can be classified as anti-enzymatic, antimicrobial, and antioxidant.

Table:1. Chemical preservatives & Their Mechanism of Action [32]

Preservatives	**Types of food were used**	**Act on**	**Optimum pH**	**Mechanism of action**
Propionates	Cheese, baked foods, help to prevents ropiness in baked product	The growth of *Bacillus subtilis* is responsible for ropiness.	Below 5.5	Inhibit microbial growth
Sorbic acid	Cocktail, dried fruits, cheese, pickles and baked goods	Effective against Salmonella coliforms .	pH (5.5-6)	It may disturb transportation through membranes and causes death of cells.
Nitrites and nitrates	Used in meat curing	Acts on *Clostridium botulinum*	-	Used to block the synthesis of ATP by glycolysis.
BHA and BHT	It is used in meat, baked foods, cereals and also an antioxidant	Acts on free radical scavenger	PH-4.8	Acts by preventing the spread of the radical scavenge.
Benzoic acid	Used in jam, jellies, juices and pickles	Acts on yeast and molds	PH-2.5-4	Retard cellular uptake of substrate molecules
Sodium benzoate	Salad dressings, jams, juice,	It serves as an antibacterial and	PH-2.5-4	Acts through entering cell membranes in the food

	fruits and pickles	fungicide preservative.		items and balancing their pH level, raising the level of acidity of food.
Sulfites and sulfur dioxide	Applied in the raisins, apricots, meat products, light beverages, beer, & wine.	Prevent the growth of germs, yeast & mould.	Acidic PH less than 4	React with cellular adenosine triphosphate (ATP). Inhibit cellular metabolism enzymes.

3. Effects of food preservatives:

Supplements rarely cause short-term problems for the majority of people. However, 50 of the 400 now permitted throughout Australia were associated to negative outcomes in specific individuals. Certain nutritional products are more prone to trigger reactions of allergy compared to another. Color is one of many additions used to produce marketable food, which frequently causes allergies.

These extremely delicate scenarios include:

Digestive difficulties episodes of diarrhea and lightheadedness. Agitation, hyperactivity, and sleeplessness are all examples of mental problems.

Breathing problems, a form of asthma hay fever, & sinus.

The skin concerns include problems with stool, edema, itchiness, and rash.

When a person consumes or is exposed to food additives on a regular basis, the effects may be harmful gradually or suddenly. It's possible to experience headaches, energy swings, and other symptoms. in the response or actions of the immune system. Long-lasting effects might raise the chance for tumors and heart attack or stroke. Certain old synthetic preservation agents cause concern due to studies linking them to respiratory and other health issues. Individuals with immunological deficiencies may have anaphylactic shock, which can be lethal in minutes if emergency medical attention is not given. The following are both of the primary sources of hazardous substances. The initial category includes people that are actively involved in the processing task. These include sweeteners, flavor enhancers, colorants, and texture agents. This is explained in detail on the label and is readily apparent with a little research and a comprehensive analysis of the data given to the supplier. Food handling, storage, and packaging are another major source for additives to food, yet they are rarely listed on food labels. Giving kids food that is free of additives is the greatest option. Many foods sold in stores include one or more types of preservatives. All of these drugs create various health issues. Ingredients are used to maintain the excellent nutritional value of food. Food preservation agents are compounds added to food to inhibit the development of microbes, mold, & fungus. Numerous individuals have sensitivities

to specific substances in food and colors. While anyone reacts after consuming anything, it is assumed they have a sensitive. However, certain individuals do not react for a day or two, making it impossible to determine what is causing the problem. When it is suspected that a food item is the source of the allergy, the blood is combined with chemicals recognized to induce allergies. Preservative-free diets are recommended due to the potentially fatal reactions that these compounds might cause. [32]

4. Preservatives:

Antioxidants and Antimicrobials.

Table 2: Antioxidants [32]

Chemical substances	Mechanism of action
Tocopherols	A free radical scavenger
Butylated hydroxy anisole (BHA)	A free radical scavenger
Ascorbic acid	Oxygen scavenger
Citric acid	Enzyme inhibitor
Sulfites	Enzyme inhibitor

The terms "butylated hydroxytoluene" & "butylated hydroxy anisole" refer to the same compound. Butylated hydroxy anisole & hydroxytoluene two synthetic monocyclic phenolic chemicals. Their antioxidant qualities make them popular choices for food preservatives in a range of food compositions. Research has indicated that BHA and BHT may pose health risks, such as childhood hyperactivity, liver, kidney, and lung damage, and most notably, cancer. [33].

Among the well-known antioxidant vitamins are:

a) Vitamin C is present in ascorbic acid (E300): Jams, dried potatoes, sliced fruit, and beers all contain it. The internet-based food-related journal is named after the publication Current Investigations in the Science of Food. They help prevent food from becoming discolored by halting oxidation.

b) Citric acid (E330): Reduces food discoloration and helps preserve the pH balance in jams and jellies. They are also a part of dry soup, biscuits, and drinks that contain alcohol.

c) Tocopherols, or E307: are antioxidants that are used in oils and meat pies to slow down the oxidation of vitamins and fatty acids.

d) Butylated hydroxy anisole E320: This chemical slows the breakdown of vitamin A and lipids. Cheese and crackers both use this antioxidant.[32]

Table 3: Antimicrobials: [32]

Chemical Substances	Mechanism of action
Nitrates and nitrites	Blocks digestive enzymes and disturbs the membrane of cells function.
Sulfites and sulfur dioxide	Stop enzyme and produce more substances like bacteria and yeast.
Benzoic acid	Break the membranes of cells and block enzymes like molds, microbes and yeasts.

Acetic acid	Disrupt the membrane of cells work, which includes yeasts, bacteria, and molds.
Sorbic acid	Inhibit yeast, bacterium, and mold spore formation.

e) Nitrites and Nitrates:

The oxygen-carrying protein hemoglobin binds to nitrate and undergoes a chemical transformation to create methemoglobin, which obstructs oxygen transport to tissues and may give skin a blue color. Higher levels of nitrate and nitrite have been associated with a higher risk of leukemia, brain tumors, and adult cancer. Drinking water tainted with nitrate and nitrite has been related to methemoglobinemia, or reduced oxygenation of hemoglobin. Because of the cyanotic (low oxygen) symptoms brought on by low blood oxygen, it is often referred to as "blue baby syndrome". [33]

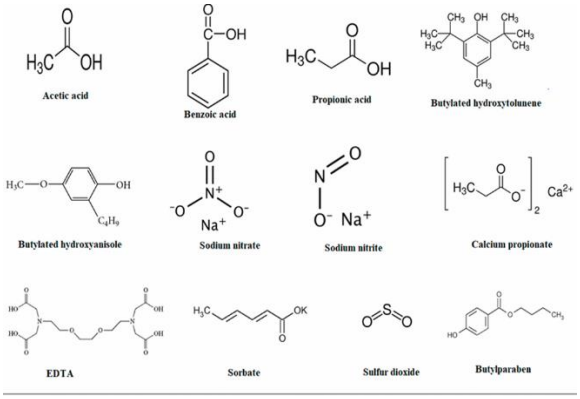

Figure 2: Examples of Antimicrobial agent.[34]

5. Chemistry of polyphenols:

Phenolic compounds have been demonstrated to possess antibacterial qualities in addition to their well-known benefits as antioxidants, antidiabetic agents, hypotensive agents, anti-inflammatory agents, anticancer agents, immune system boosters, and enhancers of brain function. For more information, see a number of previously published articles on various biologic actions of polyphenol. Because of their bioactivity and nutritional value, plant-based antimicrobials represent a promising class of natural preservatives that are safe, nourishing, and offer additional advantages. Extracts from plants are being consumed by humans for centuries. Polyphenols, known as metabolites that are secondary to plants, are derived from the polyketide path, specifically shikimate. They are vital for the synthesis of pigments, resistance to environmental stresses like UV rays and pathogen defense systems, and their role as chemical messengers makes them very different throughout plants. Their composition and structure are significantly influenced by plant species and environmental conditions. Presently, over ten thousand chemicals that are phenolic have been found, the vast majority of which are flavonoids. They are found primarily in vegetables, fruits, grains, coffee beans, wine, tea, & chocolates.

Polyphenols, also are frequently classified according to their origin, structural characteristics, and biological activity. Consequently, categories of polyphenols include tannin polymers, lignans, stilettoed coumarins, flavonoids, and phenolic

acids. Glycosides, which are found naturally, are linked to the carbon skeleton at various locations by means of distinct sugar molecules and their acylated forms. [34]

5.1. Polyphenols have antimicrobial properties:

Resistance to antibiotics is a major worldwide healthcare concern in recent decades. It is predicted that over 70 percent of harmful microbes are antibiotic-resistant. This has substantial public health consequences, and in light of previous discoveries, an urgent hunt for novel antibacterial agents is required. Plants have been used for food and healing since ancient times. [35] Numerous studies have demonstrated the antibacterial qualities of some plants and their extracts. Natural compounds with antimicrobial properties include terpenoids, alkaloids, peptides, and phenolic secondary metabolites (polyphenols).[36] Those metabolites from plants are shown to possess both immediate and secondary inhibiting impacts on biofilm development, quorum sensing, and the efflux pump. in addition, he created a quantitative framework to determine that structure-activity connection among phytochemicals and food spoilage of pathogenic microbes. The researchers postulated the functions of 35 polyphenols (1g L−1).[37] would be detrimental to microorganisms classified as Gram-positive (Escherichia coli, Pseudomonas aeruginosa, and Salmonella enteritidis) and Gram-negative (Bacillus subtilis, St. aureus, and Listeria monocytogenes). Their findings demonstrated the robust interaction between polyphenols and bacterial surfaces to provide antibacterial activity. This largely has to do with the charge, electrical properties, and lipophilicity of the polyphenols. They also observed that the effects of polyphenols were dose- and stress-dependent. [38]

5.2. Flavonoids:

In some plant sections, flavonoids are broadly dispersed, and they are present in all photosynthesizing cells. Their broad-spectrum antibacterial capabilities stem from their ability to form complexes with bacterial membranes, soluble proteins, and extracellular proteins. Specific hydroxyl groups on flavonoids' aromatic rings amplify their antimicrobial activity against microorganisms. On the other hand, methylation of the active hydroxyl groups usually results in decreased activity. When hydrophobic substituents such phenyl groups, alkylamino chains, alkyl chains, and heterocyclic moieties with nitrogen or oxygen are introduced, all flavonoids frequently exhibit enhanced activity.[39]

6. Use Chitosan's to Preserve Fruits and Vegetables:

Crustaceans & arthropods' exoskeletons include the polycation biopolymer chitosan. Chitosan has N-deacetylated product of chitin or straight polysaccharide having various levels of N-acetylation. It contains a minimum of 20% (1,4)-2-acetamido-d-glucopyranose as well as greater than 80% (1,4)-2-amino-d-glucopyranose.[40] Chitosan and its byproducts are biodegradable, biocompatible, bio-adhesive, and nontoxic, making them helpful in food, medicine, agriculture, and wastewater treatment. Chitosan effectively inhibits a variety of microorganisms, including fungal and bacterial species. Chitosan's antibacterial effect is influenced by a number of parameters, including its type, level of polymerization, natural nutrient content, and the chemical composition of the host, nutrients, or substrate. [41]

Apart from this, edible biopolymer-based coatings for bioactive compounds that restrict the passage of oxygen, moisture, solute transporters, and odors are another unique application of chitosan. Some recent papers have reported on the use of chitosan as a bioactive film in food preparation uses, including seafood preservation.[42]

6.1. Chitosan's characteristics:

The process of making chitons from soluble and deacetylated chitosan involves removing acetyl groups from chitin, which are linked to the amine ions at the second position, C2, of the glycan chain. Chitosan is a highly deacetylated version of chitin, is produced via hydrolysis of chemicals into a solution of alkaline at high temperatures. The degree of deacetylation varies depending on the chitosan production process used. Chitosan is easily soluble in diluted acidic solutions with a pH below 6.0, but chitin is insoluble in most organic solvents. This is because chitosan's main amino groups have a strong base (p ka = 6.3). The presence of amino groups demonstrates that pH has a significant effect on the charged state.[43]

6.2. The mechanism of chitosan's antimicrobial activity:

As a cationic biopolymer, it has antibacterial properties that vary depending on pH, quantity, weight of the molecular, polymerization level, and linkage. Chitosan solution is very stable for a long time, but in order to show antimicrobial efficacy against a variety of foodborne pathogens, it must be able to maintain its stability at a neutral PH. The fundamental mechanism of antibacterial activity is electrostatic contact to the microbial cell wall, membrane of the cell, and cytoplasmic components. Studies have shown that chitosan is efficient towards gram-positive as well as gram-negative bacteria. such as Escherichia coli, have an outer membrane that is made up of an asymmetrical lipid-protein bilayer known as lipopolysaccharide (LPS). The core anionic charges of LPS molecules have essentially been stabilized. The divalent cations (Ca2+, Mg2+) found in the outer membrane are primarily responsible for the LPS molecule. Chitosan has the potential to remove cations that are divalent at the attachment locations, reducing the connection among LPS particles. This breakdown of the membrane permits positively charged particles to enter via electrostatic contact, resulting in cell lysis. Whereas gram-positive and gram-negative bacteria, gram- do not have a membrane on the outside. Chitosan, as a poly-cationic long chain polymer, can more easily cling to gram-positive bacteria such as Staphylococcus aureus. This explains why chitosan is more efficient in suppressing gram-positive bacteria than gram-negative bacteria. According to published research, gram-positive microbes that have poly-anionic surface polymers like lipoteichoic acid and teichoic acid may interact with internal molecules.[44]

6.3. Use of Chitosan's in Food Preserving:

Food-friendly films and finishes Chitosan's usage as a coating that is edible is the subject of extensive research. Chitosan is defined as the formation of a thin film over the outermost layer of the product that it is intended to preserve. In addition to providing a layer of protection for food and beverages, edible films or coatings may be ingested alongside the covered item. in food and beverage preservation uses, the creation of a moist and air obstacle can end up in a decrease in weight and a reduction of the rate of respiration, delaying rotting and increasing the lifespan of the item. The usually measured obstacle qualities are oxygen permeability (OP) and water vapor permeability (WVP). [45] Edible chitosan films are extremely good oxygen permeation barriers but having very low water vapor barrier qualities. Films & coatings generate specific permeability, namely towards oxygen, carbon dioxide, and ethylene. They also prevent the formation of bacteria and allow some control over the respiration of fruits. Cucumbers (various waxes), tomatoes (mineral oil), apples (shellac and carnauba wax), and citrus have all been preserved for a very long-time using coating techniques. Chitosan-coated tomatoes suppressed the growth of the Penicillium, species of Aspergillus, Rhizopus, for stolonifera, and Botrytis cinerea, among others. Furthermore, chitosan has the capacity to prevent a variety of

fungal infections that degrade fruit quality during storage. [46]

Furthermore, chitosan itself has the ability to inhibit a number of fungal infections that lower fruit quality during storage. Furthermore, research was carried out. Studies on the 20% loss of papaya (Carica papaya L.) have also been conducted. Papaya post-harvest deterioration is a microbiological process that happens when the fruits become susceptible to several market illnesses, which lowers their acceptability and shelf life.

7. Natural Coatings to Extend Fresh Fruits and Vegetables' Shelf Life and Preserve Their Quality:

The naturally existing waxy protective coatings on product surfaces are replaced with thin layers of edible substance. This technology lowers deterioration while maintaining produce quality and increases the life span of newly harvested fruits with no the use of anaerobic environments. We call this edible coating. Coatings like these facilitate gas exchange while also preserving freshness, flavor, smell, texture, and nutritional value. Eating layers & coating that act is an obstacle to air & water create the fruit's altered atmosphere. This keeps the fruit fresher longer and increases its shelf life. They also act as a barrier, keeping pathogens out. Eating layers and coatings that act as an obstacle to gasses and moisture create the fruit's altered atmosphere. They improve hygiene by forming a barrier against bacterial attacks. A variety of active substances, including anti-browning agents, coloring agents, taste buds, vitamins and nutrients, and condiments, may be included to a matrix of polymers and taken alongside the fruits to improve safety as well as nutritious and visual aspects. Because edible coatings are biodegradable, they contribute to the reduction of waste caused by synthetic packaging. [47]

7.1. Polysaccharides:

Polysaccharides are among the four primary categories of biomolecules; they are very stable, safe, non-toxic, and biodegradable macromolecules. In edible coating formulations, Starch & its analogs, cellulosic derivatives, and alginate, also carrageenan, chitosan, the pectin and other gum are the primary carbohydrates that can be exploited.

7.2. Cellulose:

Cellulose is a very typical polymer from nature found around the world. Its solubility in water and closely linked crystalline structure make it difficult to apply as a covering. However, a number of commercially available cellulose derivatives, such as methyl cellulose (MC), carboxyl methyl cellulose (CMC), hydroxyl propyl methyl cellulose (HPMC), and hydroxyl propyl cellulose (HPC), can overcome some of the original form's restrictions. The coatings used on the shells MC, HPC, and CMC are examined.[47]

7.3. Organic volatiles:

Tomatoes that had just been sliced were kept at 5°C for 15 days utilizing naturally volatile compounds like methyl jasmonate, alcohol, oil of tea tree, and garlic oil. Inhibiting microbial growth was more effective when methyl jasmonate and ethanol were combined than when they were used separately. Additionally, this mixture -maintained color and rigidity better than the other antimicrobial preservatives. It was also able to hold down its higher quantities of phenolic component, ascorbic acid, and lycopene thanks to methyl jasmonate. The impact of including vanillin, lemongrass, and oregano oil were added to an edible coating made of apple pulp and alginate were studied in terms of fresh-cut "Fuji" apples' shelf life. Over 21 days at 4°C, the coating with 0.3 percent w/w vanillin performed the best in terms of sensory quality. The study found that all other antimicrobial coats considerably reduced the growth of molds, yeast & other psychrophilic aerobes.[47]

7.4. Aloe vera gel:

Bio-preservation is a unique food preserving process that attempts to increase the safety of food and its shelf life. by utilizing natural or regulated bacteria and/or antimicrobial compounds. Postharvest technologies have long included the use of plant-based remedies to extend the shelf life of fruits and vegetables. Plant-based chemicals have been used as bio-preservatives for fresh fruits and vegetables in recent times. Aloe Vera gel is one of the most promising bio-preservatives and has a lot of potential for usage on most fresh fruits and vegetables. For ages, China, Japan, and India have utilized aloe vera as a natural remedy for skin rejuvenation. Because of the gel's antibacterial properties, a Spanish postharvest researcher has been studying it for a select few fresh fruits since 2005. They discovered that aloe vera extracts prevented or postponed postharvest quality declines in "Crimson Seedless" grapes. Furthermore, it was found that aloe vera extracts may be able to lessen the quality losses that occur after harvesting "Artic Snow" nectarines. Edible aloe vera gel covers most fruits and vegetables. Fruits coated in edible materials provide a number of benefits, such as better color, a glossier appearance, less weight loss, and longer storage and shelf life since the microbial decomposition is prevented. Using 100% aloevera gel, papaya fruit has been kept at room temperature.[47]

8. Plant-Based Natural Preservatives and Their Use in Meat and Meat Products:

Natural preservatives derived from plants exhibit antibacterial properties that are intimately linked to flavonoids, phenolics, and polyphenols. Different classifications and structures apply to polyphenols obtained from plants, phenolic compounds (caffeic acid, rosmarinic acid, gallic acid, ellagic acid, cinnamic acid), flavones (luteolin, apigenin, chrysoeriol), flavanols (catechin, epicatechin, epigallocatechin, gallocatechin, and their gallate derivatives), flavanones (hesperidin, hesperetin, heridictyol, naringenin), flavonols (quercetin, kaempferol, myricetin), isoflavones Polyphenols are known to have high antibacterial effects. Although the precise mechanism of action against bacteria remains unknown, past study has identified the following: (1) molecules that disrupt cell membranes, such as the hydroxy group (OH-), resulting in the leakage of intracellular components, the inactivation of metabolic enzymes, and the extinction of adenosine triphosphate (ATP); (2) contact pH modifications to the surroundings through increased proton concentration, intracellular pH reduction through acid-molecule separation, and altered permeability of bacterial membranes; and (3) organic acid molecules present in plant extracts may influence. discusses how food-borne illnesses and bacteria that cause meat and meat products to deteriorate are avoided by using preservatives made from plants. [48]

Table:4. Plant- based natural preservatives & their use in meat & meat products. [22]

Sources	Forms	Addition conditions	Meat and meat products	Storage conditions	Target microorganism	Antimicrobial activities
Rosemary	Ethanol extract Essential oil Essential oil	45% 5mg/mL 0.2%with modified atmosphere packaging	Beef Chicken Poultry fillet	4 °C for 9 d 18 °C for24d 4 °C for 1 d	*Listeria monocytogenes* *Salmonella Enteritidis* Coliform Total viable counts Lactic acid bacteria Anaerobic bacteria	2log CFU/g 1log CFU/g 1.75 log CFU/g 0.87 log CFU/g 1.05 log CFU/g 1.28 log CFU/g 0.1 log CFU/g

					Listeria monocytogenes	
Sage	Essential oil	0.1%	Mechanically separate-d chicken meat	~18 °C for 9 months	Total viable counts psychrotrophic Bacteria *Enterobactococc-us* Coliform *Enterococcus spp.* *Listeria monocytogenes*	0.5logCFU/g 0.2logCFU/g 0.9logCFU/g 1.5logCFU/g 1.6logCFU/g 1 log CFU/g
Cinnamon	Essential oil Essential oil	5.0% 0.6% with chitosan edible coating under modified atmosphere packaging	Ground beef Roast duck slice	-18 °C for 60 d and 8 °C d for 14 d 2 °C for 14 2 °C for 7 d	*Listeria monocytogenes* Total viable counts *Enterobacteriaceae* Lactic acid bacteria	3.5-4.0 log CFU/g 1 log CFU/g 1 log CFU/g 0.7 log CFU/g
Turmeric	Powder Powder Residue using supercritical fluid extraction and pressurized liquid extraction	1% 3%with 2 kGy of gamma irradiation 5% with edible coating using starch and bovine gelatin	Chicken breast meat Chicken meat	4 0c for 48 d 4 0c for 14 d	*Escherichia coli* Total viable counts coliform Total viable counts Lactic acid bacteria Psychotropic bacteria	0.2 log CFU/g 0.2 log CFU/g Bactericidal effect 2.21 log CFU/g 1.01 log CFU/g 1.65 log CFU/g
Chestnut	Inner shell extract leaf extract	1 mg/ML 1000 mg/kg	Chicken Beef patties	4 0c for 4 d 2-1 0c for 18 d	*Campylobacter jejuni* Lactic acid bacteria *Pseudomonas spp.*	3 log CFU/g 0.37 log CFU/g 0.33 log CFU/g

9. Regulation of food and preservatives:

Preservatives of natural, artificial, and microbial origin are used to maintain the shelf life and quality of various food products. Natural techniques, such as smoking fish and meat and adding salts, have been used for food preservation for years. Freezing and refrigeration are other natural methods of preserving food. Preservatives for food not just raise the nutritious value of foods, but also improve their appearance. various regulatory authorities create food and preservative laws, specifying which components and in what quantities should be added to food and food supplements to ensure that consumers do not experience any adverse health effects. We refer to such compounds as widely accepted as safe (GRAS). All nations in the world have various regulatory issues, even though they should be similar. Before anything is added in the country of Nigeria, the National Agency for Food and Drug Administration and Control (NAFDAC) must give its clearance. The food and medicine sectors are required to abide by a number of regulations set forth by the Nigerian Medicine and Related Products Act of 1996, or face penalties. These regulations include the following: including medications as food additives on labels; listing artificial coloring and food color mixes; carrying

over food additives and processing aids; and adding particular information to food additives. [32]

CONCLUSION:

Manufacturers and processors of food are looking for natural preservatives for food that have wide antimicrobial effects. Naturally anti-oxidants, edible coating agents, and antibacterial compounds are critical defenses against bacteria and other degrading processes that can affect food and other products. Fruits, vegetables, spices, and herbaceous perennials are the most commonly used plants in the food business as natural antimicrobials to prevent food-borne infections and extend food shelf life. Peptides, or polypeptides, are the most frequent antibacterial chemicals in mammals. Numerous chemicals produced by bacteria may be useful in the fight against harmful and degrading microorganisms. The majority of antibacterial chemicals derived from microorganisms are produced as byproducts of food fermenting. There are several aspects that can impact the antibacterial qualities of natural goods, including the kind of plant utilized, the time of year it is collected, its development, and the method of extraction. Food applications, food ingredients, and food processing can change these organic antibacterial compounds. For this reason, Transport and storage may necessitate larger concentrations than those seen in laboratory media. The purpose of this review is to look at the safety and toxicity literature on preservatives like microorganisms, essential oils, tea fermented by microbes, olive polyphenols, and parabens. This study shows how effective preservatives are in food and food items.

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