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A Review on Preservatives Present in Packaged Food Items

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Abstract

Packaged food products have become an essential part of modern lifestyles due to their convenience, extended shelf life and easy availability. To maintain food quality, safety, and freshness, manufacturers use various preservatives that inhibit microbial growth, prevent oxidation, and preserve texture, flavor, and color. While food preservatives play a crucial role in reducing food spoilage and ensuring food security, concerns have been raised regarding their excessive consumption and potential health effects. This review examines the types, functions, applications, benefits, and possible health risks associated with preservatives commonly used in packaged food items.

Food spoilage has been a universal problem all the way through past time, and to a great extent of the spoilage is caused by the action of microorganisms or enzymatic reactions during the storage of food. Thus, using chemical compounds could check or delay food spoilage and this has lead to the great success of these compounds in the treatment of human diseases. Salt, sugar, honey, vinegar, edible oil and spices are natural preservatives considered safe for consumption. Benzoate, sorbates, nitrates, sulphur dioxide, propionates, antioxidants and nisin are synthetic preservatives that are extensively used in the food industry.

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1. Introduction: Preservative is a substance used to prevent spoilage of packaged food items from microbes and prevent their oxidation. Preservative are food additives that reduce the risk of food borne infections, decrease microbial spoilage, and preserve fresh attributes and nutritional quality. Antimicrobials work by either killing microorganisms or creating an environment (e.g., by increasing acidity) where they cannot survive and reproduce. Antioxidants work by preventing oxygen from reacting with food components, particularly fats, thus halting the oxidation process that leads to spoilage. Preservatives play a crucial role in the food industry for several reasons. It help to extend the shelf life of food products, reducing waste and ensuring that food remains safe and edible for longer periods by inhibiting the growth of harmful microorganisms. Preservatives help to prevent food borne illnesses and ensure that food is safe for consumption. Preservatives help to maintain the taste, texture, and appearance of food products, ensuring that they remain appealing to consumers. Extended shelf life and reduced spoilage translate to cost savings for both consumers and producers, making food more affordable and accessible. Food preservatives are of two types, Class I and Class II.

This review explains the various types of food preservatives, natural (Class I) {Salt, sugar, honey, vinegar, edible oil and spices} and synthetic preservatives (Class II), {Benzoate, sorbates, nitrates, sulphur dioxide, propionates, antioxidants and nisin} including antioxidants and antibacterial agents. Today, synthetic preservatives are more commonly used than natural ones.

2. Class I preservatives: Class 1 preservatives are natural in origin derived from plants and minerals like salt, sugar, vinegar, honey, spices, and edible oils, which are used traditionally to prevent food spoilage by inhibiting microbial growth. These have no strict usage limits as they are generally considered as safe in normal food quantities and often found in everyday kitchens. These traditional methods work by reducing water activity, creating unfavorable conditions for microbial growth, or by their natural antimicrobial properties, and extending shelf life of food without using synthetic chemicals.

Figure 1. Class I Preservatives

2.1. Salt (Sodium Chloride): From ancient time Salt has been used as a preservative. Pickling of fruits and vegetables and salting of fish and meat are extensively practiced. The anti- microbial activity of sodium chloride is basically related to its ability to reduce water activity and generate adverse conditions for microbial growth. As the salinity of the external medium is increased, microbial cells are subjected to osmotic shock and rapidly lose water that causes shrinking of microbial cells. That result in ceasing the growth of the cells which makes cells either die or remain inactive.

2.2. Sugar: Sugar acts as a natural preservative by creating a high osmotic pressure environment that dehydrates and kills microorganisms, such as bacteria and mold, by drawing out their moisture. It commonly used in jams, jellies, and candied fruits, high concentrations of sugar (above 68%) reduce water activity, preventing food spoilage.

2.3. Vinegar (Acetic Acid): Vinegar adds acidity, and creating an inhospitable environment for growth of microorganisms. Synthetic vinegar (dilute acetic acid) and brewed vinegar are widely used as acidulants and antimicrobials. Vinegar pickles are common in our country. Acetic acid is more effective against yeasts and bacteria than moulds. Generally, 1-2 % acetic acid is sufficient to inhibit the growth of most of the organisms.

2.4. Honey: Honey contains natural antimicrobials and low water activity. Honey has been recognized worldwide as a highly nutritive food used widely in the food industry as a natural food preservative. Several studies have reported that honey is associated with anti-browning, antioxidant, anti-inflammatory, antiviral and antibacterial properties, which offer scope for its applications in food industries. Honey has the potential to restrict the growth of various food spoiling bacteria such as *Escherichia coli, Clostridium perfringens, Staphylococcus aureus* and *Salmonella species*, so it prevent food contamination. This antibacterial property of honey is attributed to its high sugar content, hydrogen peroxide formation and proteinaceous compounds. Number of evidences has reported that commercial milk samples stored at 4 °C in the presence of honey restrict opportunistic bacterial growth compared to those stored in the absence of honey. This antibacterial property and preservative nature of honey improve the quality and shelf life of various food products. Furthermore, the preservative potential of honey is demonstrated by its prevention of lipid oxidation and other deteriorative oxidative reactions, such as enzymatic browning of fruits and vegetables [1].

2.5. Edible Oils: When fruits or vegetables are submerged in oil, it builds a protective layer that minimizes its exposure to oxygen and moisture which are responsible for food spoilage. Certain oils, like mustard oil, have natural antimicrobial properties that further inhibit the growth of bacteria and fungi. Different types of oils can be used for preservation, such as Mustard oil, Sesame oil, Olive oil, each bringing its own unique flavor and benefits. Preserving fruits and vegetables in oil extend its shelf life, enhance flavor and have health benefits. These oils are rich in healthy fats, antioxidants, and other beneficial compounds that promote overall health. Oil-preserved pickles are very common in Indian cuisine.

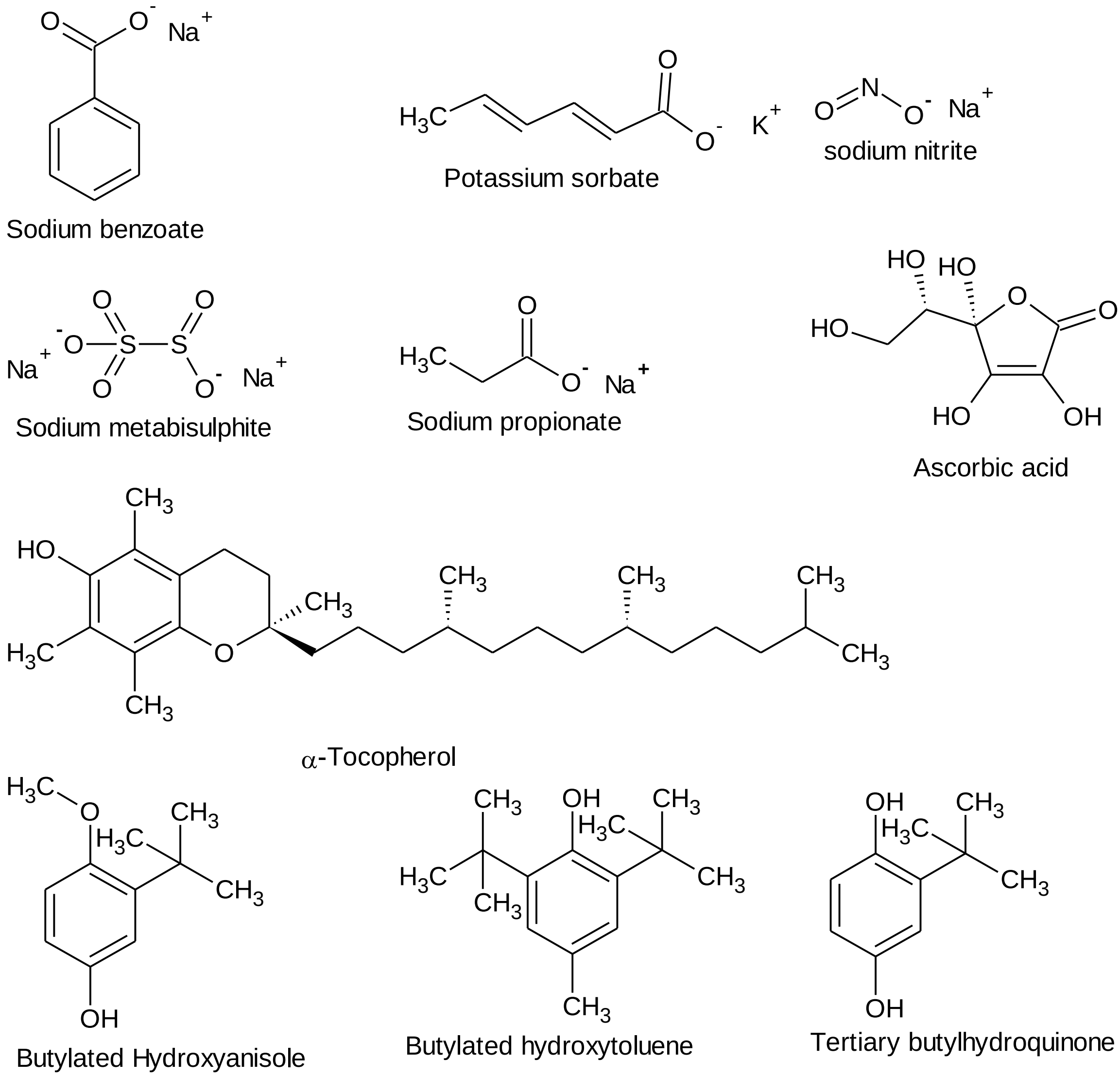
2.6 Spices: Spices contain compounds that have natural antimicrobial properties (e.g., cinnamon, cloves). Many chemical substances in spices (alkaloids, terpenes) have been shown to have antimicrobial properties. Spices act as natural preservatives by containing antimicrobial, antifungal, and antioxidant compounds that inhibit growth of microorganism and delay lipid oxidation. Common preservative spices include clove, cinnamon, oregano, rosemary, thyme, garlic, and mustard seeds, which help in extending the shelf life of food, particularly meat.

Addition of Class I preservative in any food is not restricted.

3. Class II preservatives are synthetic preservatives: Class II preservatives are synthetic, lab-created antimicrobial compounds used in food to extend their shelf life. Their usages are strictly regulated by authorities like FSSAI due to its potential health risks at high doses. Common examples of Class II preservatives include sodium benzoate, sorbates, sulfites, nitrites, and parabens, often used in processed foods [2].

3.1. Benzoates: Benzoates, primarily sodium benzoate (211), are highly effective, water-soluble, and cost-efficient antimicrobial preservatives and are frequently used to extend the shelf life of acidic foods like salad dressings, fruit juices, jams, carbonated drinks, sauces, condiments, pickles and frozen yogurt. It inhibits mold, yeast and bacterial growth. Sodium benzoate converts to benzoic acid in acidic environments ($pH < 4.5$), which penetrates microbial cells and inhibit their growth. It generally recognized as safe by the FDA, with permitted usage levels often fixed around 0.1% by weight. The FDA allows up to a 0.1% concentration of sodium benzoate by weight in foods and beverages. The WHO has set the acceptable daily intake (ADI) level for sodium benzoate to 0–2.27 mg per pound (0–5 mg per kg) of body weight. People generally don't exceed the ADI through a normal diet. When sodium benzoate combined with ascorbic acid (Vitamin C) in beverages, it can form benzene, a carcinogen. Some studies suggest its potential for allergic reactions and it can cause metabolic side effects, when consumed at very high, non-compliant levels [3].

Figure 2. Class II Preservatives: Synthetic preservatives-



3.2. Sorbates: Sorbates includes sorbic acid (200) and its salts (potassium sorbate 202, calcium sorbate 203), that are widely used as safe food preservatives for extending its shelf life. It acts as strong antifungal (against molds and yeasts) and antibacterial agents and used in preservation of dairy products (Soft cheeses, yogurt.), baked goods (Cakes, pastries, bread, tortillas.), and fruit products (maaza cold drink, frooti, kissan mixed fruit jam, sauces, dressings, dried fruits, fruit juices). It is more effective in acidic conditions and preserves food without altering its flavor. They are considered GRAS (Generally Recognized As Safe) by the FDA and are metabolized into harmless compounds like carbon dioxide and water in the body, making them a popular alternative to other preservatives like benzoates. Rare mild skin or digestive issues may occur in sensitive individuals. In pure form, potassium sorbate is a skin, eye, and respiratory irritant. Concentrations up to 0.5% are not significant skin irritants. As a food additive, potassium sorbate is used as a preservative in concentrations of 0.025%–0.1%, which in a 100 g serving yields an intake of 25–100 mg. In the United States, no more than 0.1% is allowed in fruit, butters, jellies, preserves, and related products. Up to 0.4% has been studied in low-salt, naturally-fermented pickles, and when combined with calcium chloride, 0.2% made good quality pickles. Potassium sorbate has about 74% of sorbic acid's anti-microbial activity. When calculated as sorbic acid, 0.3% is allowed in cold pack cheese food. The upper pH limit for effectiveness is 6.5. The maximum acceptable daily intake for human consumption is 25 mg/kg, or 1.75 g daily for an average adult (70 kg). Under some conditions, particularly at high concentrations or when combined with nitrites, potassium sorbate has shown genotoxic activity in vitro [4]

3.3. Nitrites: Nitrites are essential curing agents used mainly in processed meats (bacon, sausage, hot dogs) and pickled products to prevent the growth of the deadly bacteria *Clostridium botulinum*, that causes botulism. They act as preservatives by inhibiting bacterial spoilage, controlling lipid oxidation (preventing rancidity), and giving their characteristic pink color and savory flavor to the cured meats. Nitrites react with meat proteins and produce the desirable, stable pink color and unique "cured" flavor. They inhibit fat oxidation, which extends the shelf life of products. While often added synthetically, nitrites are also found naturally in vegetables and leafy greens (like spinach). Under high heat (e.g., frying bacon), nitrites can form compounds called nitrosamines, which are linked to cancer risks. Because of this, their usage is strictly regulated. Due to health concerns regarding nitrosamines, the food industry is actively investigating healthier, natural alternatives to nitrites, such as celery powder or other plant-based extracts [5].

3.4. Sulfites: Sulfites are chemical preservatives and antioxidants. It includes sulfur dioxide, sodium sulfite, and metabisulfites. It widely used to extend shelf life of foods like dried fruits, vegetables, wine, beer, cider, processed potato products (French fries, instant mash), fruit juices, cordials, jams, condiments, vinegar, and pickled foods. Sulfites inhibit the growth of bacteria, yeasts, and molds in foods and beverages. It prevent enzymatic and non-enzymatic browning (fermentation) in dried fruits (apricots), vegetables, fruit juices, wine, beer, and processed potatoes.

Sulfites are normally introduced to seize fermentation at a desired time, and may also be added to wine as preservatives to prevent spoilage and oxidation at several stages of the winemaking. Sulfur dioxide (SO_2) protects wine from not only oxidation, but also from bacteria. In fruit canning, sodium bisulfite is used to prevent browning (caused by oxidation) and to kill microbes. The sulfur dioxide released by these salts kills yeasts, fungi, and bacteria in the grape juice before fermentation. Once the levels of sulfur dioxide have subsided (about 24 hours), fresh yeast is added for fermentation. It is later added to bottled wine to prevent the formation of vinegar if bacteria are present, and to protect the color, aroma and flavor of the wine from oxidation, which causes browning and other chemical changes. Sodium metabisulfite and potassium metabisulfite are the primary ingredients in Campden tablets, used for wine and beer making. It used as dough conditioners, color stabilizers, and to inhibit discoloration in seafood and, previously, raw salad bar items.

They are generally recognized as safe for the general population but can cause adverse reactions, particularly asthma-like symptoms, in sensitive individuals. While safe for most of the population, roughly 1% particularly those with asthma, may experience sulfite sensitivity. Adverse reactions can include wheezing, chest tightness, coughing, hives, abdominal pain, and in rare, severe cases, anaphylactic shock. Due to these risks, regulatory bodies (e.g., FDA, EFSA) mandate labeling if sulfite concentrations exceed 10 ppm in food or beverages. Sulfites can occur naturally during fermentation, meaning "sulfite-free" wine is rarely truly free of them. It may cause adverse reactions in those who are sensitive to sulfites, including respiratory reactions in asthmatics, anaphylaxis, and other allergic reactions in sensitive individuals. Sodium bisulfite has low toxicity, 130 mg/kg (mice, intravenous). According to another source, the acceptable daily intake is up to 0.7 milligrams per kilogram of body weight. Sodium metabisulfite oxidizes in the liver to harmless sulfate which is excreted in the urine [6].

3.5. Propionates: Propionates (calcium 282, sodium 281, and potassium 283 salts of propionic acid) are widely used as safe antimicrobial food preservatives, particularly in bakery items. It is extensively used in bread, baked foods, cakes, cheese, dairy products, processed meats, puddings, and jams to add freshness and extend their shelf life. Propionates act by inhibiting the growth of mold and some bacteria. They obstruct the ability of these microbes to produce energy, thus preventing them from growing and multiplying. They work best in slightly acidic conditions (pH below 5.5), by disrupting microbe cellular functions. Propionates generally recognized as safe (GRAS) by the FDA and approved for use in limited amounts. It normally added in concentrations ranging from 0.1% to 0.3% by weight. While generally safe, some studies have linked high, long-term consumption to potential metabolic effects (like insulin deregulation) and behavioral issues in sensitive individuals, such as irritability or migraines [7].

3.6. Antioxidants: The oxidation process spoils most food, especially those with a high fat content. Antioxidants prevent the oxidation of fats and lipids in food, which can lead to rancidity and spoilage. Antioxidants preserve food by preventing or delaying oxidation, a process where air damages fats, colors, and nutrients, causing rancidity, off-flavors, and spoilage, thereby extending shelf life in products like oils, snacks, meats, Cakes, biscuits, candies, Cereals, cheese, chips, baked goods, margarine, vegetable oils, processed meats, seafood**,** beverages and dried fruits**.** They work by scavenging free radicals, protecting sensitive vitamins, and maintaining food quality, using both natural sources (Tocopherols: (Vitamin E), Ascorbic Acid: (Vitamin C), Rosemary Extract, Carotenoids: (like lycopene), Citric Acid) and synthetic ones {like Butylated Hydroxyanisole (BHA)**,** Butylated Hydroxytoluene (BHT)**,** Propyl Gallate and Tertiary butylhydroquinone (TBHQ)}. Citric and ascorbic acids target enzymes that degrade fruits and vegetables, e.g., mono/polyphenol oxidase which turns surfaces of cut apples and potatoes brown. Ascorbic acid and tocopherol, which are vitamins, are common preservatives. Antioxidants donate electrons to unstable free radicals, neutralizing them and stopping the chain reaction of oxidation. In fats and oils, they slow down lipid oxidation, preventing the development of unpleasant tastes and smells. They shield vitamins (like Vitamin A, E) and amino acids from degradation by air. They help preserve natural colors in meats, fruits, and vegetables [8].

3.7. Microbial Preservatives: Natural antimicrobial agents like nisin (a bacteriocin) that inhibit food spoiling bacteria. Nisin is a polycyclic antibacterial peptide produced by the bacterium *Lactococcus lactis* that is used as a food preservative for cheese, bake food, meat, dairy products and coconut waters. Nisin (234) is a naturally occurring antimicrobial peptide used as a food preservative, generally restricted to levels below 250 mg/kg depending on the product, with an Acceptable Daily Intake (ADI) of 0–2.0 mg/kg body weight. Common permitted limits include 12.5 mg/kg for cheese and dairy products, and up to 250 mg/kg (ppm) for processed cheese in the US. Dairy Products (Processed/Ripened Cheese): Generally, 12.5 mg/kg (12.5 ppm) to 250 mg/kg (ppm). Heat-Treated Meat Products: Maximum of 25 mg/kg. Clotted Cream: Maximum of 10 ppm. Pasteurized Liquid Eggs: Permitted (no specific low limit mentioned, but generally allowed). Cereal/Starch Desserts: Maximum of 3 ppm. Alcoholic Beverages: Effective at 0.25–2.5 mg/l.

In summary, for most people using foods with nisin as a preservative, side effects are rare and mild, but significant gut microbiome changes might occur with very high intake, though they are often temporary [9].

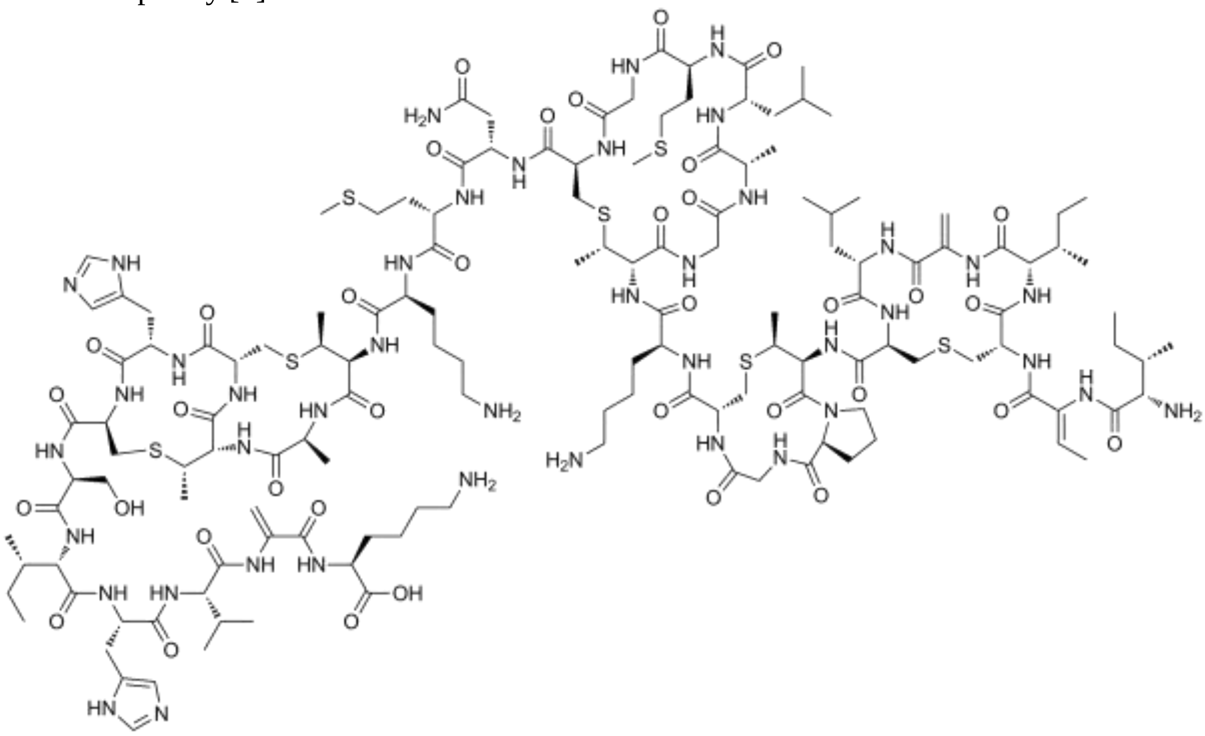


Figure 3. Nisin

Regulation: The Food Safety and standards authority of India (FSSAI) regulate the types and quantities of chemical preservatives allowed in food products.

Conclusion: Preservatives, both natural and synthetic, play a crucial role in ensuring the safety, quality, and durability of our food items. By understanding the differences between Class I and Class II preservatives, we can make informed choices about the food that we consume. As class I preservative considered as safe for consumption, while class II preservatives are more effective but may have potential health risks if not used properly. So always, it's essential to rely on regulatory guidelines and scientific evidence to find the way in complex world of food preservatives. In recent years much work has done on preservatives but there is still a need to understand the chemistry of synthetic preservatives in food, and their metabolism of in humans. So, we can find the adverse effects of this preservative on their long-term use.

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