

Chemical Preservatives in Food Cause Health Problems

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ABSTRACT: A preservative is a substance or a chemical that is added to products such as food products, beverages, pharmaceutical drugs, paints, biological samples, cosmetics, wood, and many other products to prevent decomposition by microbial growth or by undesirable chemical changes. In general, preservation is implemented in two modes, chemical and physical. Chemical preservation entails adding chemical compounds to the product. Physical preservation entails processes such as refrigeration or drying.^[1] Preservative food additives reduce the risk of foodborne infections, decrease microbial spoilage, and preserve fresh attributes and nutritional quality. Some physical techniques for food preservation include dehydration, UV-C radiation, freeze-drying, and refrigeration. Chemical preservation and physical preservation techniques are sometimes combined.

KEYWORDS: preservatives, drugs, chemical, foodborne infections, food additives, chemical compounds, uv –radiation

I. INTRODUCTION

Preservatives have been used since prehistoric times. Smoked meat for example has phenols and other chemicals that delay spoilage.¹ The preservation of foods has evolved greatly over the centuries and has been instrumental in increasing food security. The use of preservatives other than traditional oils, salts, paints, etc. in food began in the late 19th century, but was not widespread until the 20th century.^[2]

The use of food preservatives varies greatly depending on the country. Many developing countries that do not have strong governments to regulate food additives face either harmful levels of preservatives in foods or a complete avoidance of foods that are considered unnatural or foreign.³ These countries have also proven useful in case studies surrounding chemical preservatives, as they have been only recently introduced.^[3] In urban slums of highly populated countries, the knowledge about contents of food tends to be extremely low, despite consumption of these imported foods.^[4]

Antimicrobial preservatives prevent degradation by bacteria. This method is the most traditional and ancient type of preserving—ancient methods such as pickling and adding honey prevent microorganism growth by modifying the pH level. The most commonly used antimicrobial preservative is lactic acid. Common antimicrobial preservatives are presented in the table.^{[5][6][7]} Nitrates and nitrites are also antimicrobial.^[8] The detailed mechanism of these chemical compounds range from inhibiting growth of the bacteria to the inhibition of specific enzymes. Water-based home and personal care products use broad-spectrum preservatives, such as isothiazolinones and formaldehyde releasers, which may cause sensitization, leading to allergic skin.^{[9][10]}

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| E number | chemical compound | comment |
|--------------|--|---|
| E200 E203 | – sorbic acid, sodium sorbate and sorbates | common for cheese, wine, baked goods, personal care products |
| E210 E213 | – benzoic acid and benzoates | used in acidic foods such as jams, salad dressing, juices, pickles, carbonated drinks, soy sauce |
| E214 E219 | – parabens | stable at a broad pH range, personal care products |
| E220 E228 | – sulfur dioxide and sulfites | common for fruits, wine |
| E249 E250 | – nitrites | used in meats to prevent botulism toxin |
| E251 E252 | – nitrates | used in meats |
| E270 | lactic acid | - |
| E280 E283 | – propionic acid and propionates | baked goods |
| E338 | phosphoric acid | used in some jams, preserves and carbonated drinks; also used for acidification and for flavouring. |
| n/a | isothiazolinones (MIT, CMIT, BIT) | home and personal care products, paints/coatings |
| n/a | formaldehyde releasers (DMDM hydantoin) | home and personal care products |

The oxidation process spoils most food, especially those with a high fat content. Fats quickly turn rancid when exposed to oxygen. Antioxidants prevent or inhibit the oxidation process. The most common antioxidant additives are ascorbic acid (vitamin C) and ascorbates.^[11] Thus, antioxidants are commonly added to oils, cheese, and chips.^[5] Other antioxidants include the phenol derivatives BHA, BHT, TBHQ and propyl gallate. These agents suppress the formation of hydroperoxides.^[6] Other preservatives include ethanol and methylchloroisothiazolinone.^[12]

| E number | chemical compound | comment |
|-------------|--|-----------------------------|
| E300-304 | ascorbic acid, sodium ascorbate | cheese, chips |
| E321 | butylated hydroxytoluene, butylated hydroxyanisole | also used in food packaging |
| E310-312 | gallic acid and sodium gallate | oxygen scavenger |
| E220 – E227 | sulfur dioxide and sulfites | beverages, wine |
| E306 – E309 | tocopherols | vitamin E activity |

A variety of agents are added to sequester (deactivate) metal ions that otherwise catalyze the oxidation of fats.^[13] Common sequestering agents are disodium EDTA, citric acid (and citrates), tartaric acid, and lecithin.^[1]

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II. DISCUSSION

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. Smoking entails exposing food to a variety of phenols, which are antioxidants. Natural preservatives include rosemary and oregano extract,^[12] hops, salt, sugar, vinegar, alcohol, diatomaceous earth and castor oil.¹⁴

Traditional preservatives, such as sodium benzoate have raised health concerns in the past. Benzoate was shown in a study to cause hypersensitivity in some asthma sufferers. This has caused reexamination of natural preservatives which occur in vegetables.^[13]

Public awareness of food preservatives is uneven.^[14] Americans have a perception that food-borne illnesses happen more often in other countries. This may be true, but the occurrence of illnesses, hospitalizations, and deaths are still high. It is estimated by the Centers for Disease Control (CDC) that each year there are 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths linked to food-borne illness.^[15]

Food suppliers are facing difficulties with regards to the safety and quality of their products as a result of the rising demand for ready-to-eat fresh food products. Artificial preservatives meet some of these challenges by preserving freshness for longer periods of time, but these preservatives can cause negative side-effects as well. Sodium nitrite is a preservative used in lunch meats, hams, sausages, hot dogs, and bacon to prevent botulism. It serves the important function of controlling the bacteria that cause botulism, but sodium nitrite can react with proteins, or during cooking at high heats, to form carcinogenic N-nitrosamines.¹ It has also been linked to cancer in lab animals.^[17] The commonly used sodium benzoate has been found to extend the shelf life of bottled tomato paste to 40 weeks without loss of quality.^[11] However, it can form the carcinogen benzene when combined with vitamin C. Many food manufacturers have reformed their products to eliminate this combination, but a risk still exists.^[17] Consumption of sodium benzoate may also cause hyperactivity.¹⁵ For over 30 years, there has been a debate about whether or not preservatives and other food additives can cause hyperactivity. Studies have found that there may be increases in hyperactivity amongst children who consume artificial colorings and benzoate preservatives and who are already genetically predisposed to hyperactivity, but these studies were not entirely conclusive. Hyperactivity only increased moderately, and it was not determined if the preservatives, colorings, or a combination of the two were responsible for the increase.^[18]

Heat and light stabilizers are added to plastics because they ensure safe processing and protect products against aging and weathering. The trend is towards fluid systems, pellets, and increased use of masterbatches.¹⁶ There are monofunctional, bifunctional, and polyfunctional stabilizers. In economic terms the most important product groups on the market for stabilizers are compounds based on calcium (calcium-zinc and organo-calcium), lead, and tin stabilizers as well as liquid and light stabilizers (HALS, benzophenone, benzotriazole).¹⁷ Cadmium-based stabilizers largely vanished in the last years due to health and environmental concerns.^[3]

III. RESULTS

Some kinds of stabilizers are:

- antioxidants these prevent autoxidation of materials and come in 3 primary forms.
- Oxygen scavengers (primarily phosphite esters such as tris(2,4-di-tert-butylphenyl)phosphite) are commonly used during the initial processing of the plastic.

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- Persistent radical scavengers prevent or slow the photo-oxidation of polymers. Traditionally these are alkylated phenols such as butylated hydroxytoluene but now also include hindered amine light stabilizers (HALS)¹⁸
- Antiozonants prevents or retards the degradation of polymers caused by ozone (ozone cracking)
- sequestrants, forming chelate complexes and inactivating traces of metal ions that would otherwise act as catalysts
- ultraviolet stabilizers are used to protect polymers from effects of ultraviolet radiation and come to 2 main types.¹⁹
- UV absorbers which essentially act the same way as sunscreens
- Quenchers, which dissipate the radiation energy as heat instead of letting it break chemical bonds; often organic nickel salts, e.g. nickel phenolates

In foods, stabilizers prevent spoilage. Classes of food stabilizers include ²⁰ emulsifiers, thickeners and gelling agents, foam stabilizers, humectants, anticaking agents, and coating agents.^[4]

Food preservation includes processes that make food more resistant to microorganism growth and slow the oxidation of fats. This slows down the decomposition and rancidification process. Food preservation may also include processes that inhibit visual deterioration, such as the enzymatic browning reaction in apples after they are cut during food preparation. By preserving food, food waste can be reduced, which is an important way to decrease production costs and increase the efficiency of food systems, improve food security and nutrition and contribute towards environmental sustainability.^[1] For instance, it can reduce the environmental impact of food production.^[2]

Many processes designed to preserve food involve more than one food preservation method. Preserving fruit by turning it into jam, for example, involves boiling (to reduce the fruit's moisture content and to kill bacteria, etc.), sugaring (to prevent their re-growth) and sealing within an airtight jar (to prevent recontamination).¹²

Different food preservation methods have different impacts on the quality of the food and food systems. Some traditional methods of preserving food have been shown to have a lower energy input and carbon footprint compared to modern methods.^{[3][2]} Some methods of food preservation are known to create carcinogens.¹⁷ In 2013, the International Agency for Research on Cancer of the World Health Organization classified processed meat—i.e., meat that has undergone salting, curing, fermenting, and smoking—as "carcinogenic to humans".^{[4][5][6]}

Implications

Burial of food can preserve it due to a variety of factors: lack of light, lack of oxygen, cool temperatures, pH level, or desiccants in the soil. Burial may be combined with other methods such as salting or fermentation. Most foods can be preserved in soil that is very dry and salty (thus a desiccant) such as sand, or soil that is frozen.¹⁸

Many root vegetables are very resistant to spoilage and require no other preservation than storage in cool dark conditions, for example by burial in the ground, such as in a storage clamp (not to be confused with a root cellar). Cabbage was traditionally buried during Autumn in northern US farms for preservation. Some methods keep it crispy while other methods produce sauerkraut. A similar process is used in the traditional production of kimchi.

Sometimes meat is buried under conditions that cause preservation. If buried on hot coals or ashes, the heat can kill pathogens, the dry ash can desiccate, and the earth can block oxygen and further contamination. If buried where the earth is very cold, the earth acts like a refrigerator, or, in areas of permafrost, a freezer.

In Orissa, India, it is practical to store rice by burying it underground. This method helps to store for three to six months during the dry season.¹¹

Butter and similar substances have been preserved as bog butter in Irish peat bogs for centuries. Century eggs are traditionally created by placing eggs in alkaline mud (or other alkaline substance), resulting in their "inorganic" fermentation

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through raised pH instead of spoiling. The fermentation preserves them and breaks down some of the complex, less flavorful proteins and fats into simpler, more flavorful ones.

Canning involves cooking food, sealing it in sterilized cans or jars, and boiling the containers to kill or weaken any remaining bacteria as a form of sterilization. It was invented by the French confectioner Nicolas Appert.^[7] By 1806, this process was used by the French Navy to preserve meat, fruit, vegetables, and even milk. Although Appert had discovered a new way of preservation, it was not understood until 1864 when Louis Pasteur found the relationship between microorganisms, food spoilage, and illness.^[8]

Foods have varying degrees of natural protection against spoilage and may require that the final step occur in a pressure cooker. High-acid fruits like strawberries require no preservatives to can and only a short boiling cycle, whereas marginal vegetables such as carrots require longer boiling and addition of other acidic elements. Low-acid foods, such as vegetables and meats, require pressure canning. Food preserved by canning or bottling is at immediate risk of spoilage once the can or bottle has been opened.⁴

Lack of quality control in the canning process may allow ingress of water or micro-organisms. Most such failures are rapidly detected as decomposition within the can causes gas production and the can will swell or burst. However, there have been examples of poor manufacture (underprocessing) and poor hygiene allowing contamination of canned food by the obligate anaerobe *Clostridium botulinum*, which produces an acute toxin within the food, leading to severe illness or death. This organism produces no gas or obvious taste and remains undetected by taste or smell. Its toxin is denatured by cooking, however. Cooked mushrooms, when handled poorly and then canned, can support the growth of *Staphylococcus aureus*, which produces a toxin that is not destroyed by canning or subsequent reheating.³

Some foods, such as many cheeses, wines, and beers, use specific micro-organisms that combat spoilage from other less-benign organisms. These micro-organisms keep pathogens in check by creating an environment toxic for themselves and other micro-organisms by producing acid or alcohol. Methods of fermentation include, but are not limited to, starter micro-organisms, salt, hops, controlled (usually cool) temperatures and controlled (usually low) levels of oxygen. These methods are used to create the specific controlled conditions that will support the desirable organisms that produce food fit for human consumption.¹

Fermentation is the microbial conversion of starch and sugars into alcohol. Not only can fermentation produce alcohol, but it can also be a valuable preservation technique. Fermentation can also make foods more nutritious and palatable. For example, drinking water in the Middle Ages was dangerous because it often contained pathogens that could spread disease. When the water is made into beer, the boiling during the brewing process kills any bacteria in the water that could make people sick. Additionally, the water now has the nutrients from the barley and other ingredients, and the microorganisms can also produce vitamins as they ferment.^[8]

Pickling is a method of preserving food in an edible, antimicrobial liquid. Pickling can be broadly classified into two categories: chemical pickling and fermentation pickling.²

In chemical pickling, the food is placed in an edible liquid that inhibits or kills bacteria and other microorganisms. Typical pickling agents include brine (high in salt), vinegar, alcohol, and vegetable oil. Many chemical pickling processes also involve heating or boiling so that the food being preserved becomes saturated with the pickling agent. Common chemically pickled foods include cucumbers, peppers, corned beef, herring, and eggs, as well as mixed vegetables such as piccalilli.³

In fermentation pickling, bacteria in the liquid produce organic acids as preservation agents, typically by a process that produces lactic acid through the presence of lactobacillales. Fermented pickles include sauerkraut, nukazuke, kimchi, and surströmming.⁴

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Preservative food additives can be antimicrobial – which inhibit the growth of bacteria or fungi, including mold – or antioxidant, such as oxygen absorbers, which inhibit the oxidation of food constituents. Common antimicrobial preservatives include calcium propionate, sodium nitrate, sodium nitrite, sulfites (sulfur dioxide, sodium bisulfite, potassium hydrogen sulfite, etc.), and EDTA. Antioxidants include butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT). Other preservatives include formaldehyde (usually in solution), glutaraldehyde (insecticide), ethanol, and methylchloroisothiazolinone. There is also another approach of impregnating packaging materials (plastic films or other) with antioxidants and antimicrobials, such as butylated hydroxyanisole, butylated hydroxytoluene, tocopherols, hinokitiol, lysozyme, nisin, natamycin, chitosan, and ϵ -polylysine.^{[17][18]}

IV. CONCLUSIONS

Biopreservation is the use of natural or controlled microbiota or antimicrobials as a way of preserving food and extending its shelf life.^[3] Beneficial bacteria or the fermentation products produced by these bacteria are used in biopreservation to control spoilage and render pathogens inactive in food.^[1] It is a benign ecological approach which is gaining increasing attention.^[13]

Lactic acid bacteria (LAB) have antagonistic properties that make them particularly useful as biopreservatives. When LABs compete for nutrients, their metabolites often include active antimicrobials such as lactic acid, acetic acid, hydrogen peroxide, and peptide bacteriocins. Some LABs produce the antimicrobial nisin, which is a particularly effective preservative.^{[37][38]}

LAB bacteriocins are used in the present day as an integral part of hurdle technology. Using them in combination with other preservative techniques can effectively control spoilage bacteria and other pathogens, and can inhibit the activities of a wide spectrum of organisms, including inherently resistant Gram-negative bacteria.^[15]

Hurdle technology is a method of ensuring that pathogens in food products can be eliminated or controlled by combining more than one approach. These approaches can be thought of as "hurdles" the pathogen has to overcome if it is to remain active in the food. The right combination of hurdles can ensure all pathogens are eliminated or rendered harmless in the final product.^[18]

Hurdle technology has been defined by Leistner (2000) as an intelligent combination of hurdles that secures the microbial safety and stability as well as the organoleptic and nutritional quality and the economic viability of food products.^[14] The organoleptic quality of the food refers to its sensory properties, that is its look, taste, smell, and texture.

Examples of hurdles in a food system are high temperature during processing, low temperature during storage, increasing the acidity, lowering the water activity or redox potential, and the presence of preservatives or biopreservatives. According to the type of pathogens and how risky they are, the intensity of the hurdles can be adjusted individually to meet consumer preferences in an economical way, without sacrificing the safety of the product.^[17]

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