Review Article

A Review on Food Preservation: Methods, harmful effects and better alternatives

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Abstract

Every living organism needs food to live. Foods have many nutrients like carbohydrates, fats, proteins, vitamins, or minerals etc. These nutrients are ingested and digested by an organism to produce energy which is required to stimulate growth and maintain normal life process. Chemical, enzymatic or microbial activities from the surrounding environment and the food itself can cause spoilage to food products. The food has limited shelf life, in order to increase the shelf life and maintain the quality certain preservatives are used in food products but these preservatives may have some harmful effects. So that nowadays consumer demand of minimally processed foods without synthetic preservatives has led to a growing interest in their replacement for more natural alternatives. Preservatives are those substances added to various food products, pharmaceutical dosage forms and cosmetic preparations to prevent or inhibit microbial growth to maintain product consistency and quality, prolong the shelf-life of food, improve or maintain nutritional value, maintain palatability and wholesomeness, provide leavening(yeast), control pH, enhance flavor, or provide color by preventing their spoilage. An ideal preservative should be effective at low concentrations, be non-toxic and compatible with other constituent of the preparation and be stable for the shelf-life of the preparation. A, B This review paper focuses on, the preservation methods of food to maintain or protect the quality of food, and the use of natural food preservatives as alternative to artificial preservatives, for safer human consumption.

Keywords: Preservation, Natural preservatives, Shelf life, Nutritional values

Introduction

Food consumed by human and animals to produce energy can be raw, processed or formulated materials which can promotes growth and required to maintain good health. In most cases, there are no limitations on food consumption but sometime the excessive consumption of certain kind of food such as carbohydrate, fat, sugar and salt, may have harmful effects on health of consumer. Food products will promote the growth of microbial because chemically, they consist of water, fat, carbohydrates, protein and small amounts of organic compounds and minerals, since all these compounds are the source energy for microbes to grow. Various preservation methods are proposed to prevent this from occurring (Rahman, 2007). A preservative is a natural or synthetic chemical that is added to different kind of products such as foods, pharmaceuticals, paints, wood, etc. to prevent their decomposition by microbial growth or by unwanted chemical changes. These preservatives are commonly added to various foods and pharmaceutical products in order to increase their shelf life (Sabir, 2016).

There are 6 classes of food as follows, which are as below:

1. Fats and sugar ex. cream, butter, sugar, soft drinks, etc.
2. Dairy products ex. yogurt, cheese, milk, etc.
3. Protein ex. poultry, eggs, meat, nuts, etc.
4. Vegetables ex. tomatoes, salad, spinach, etc.
5. Fruits ex. apples, mangoes, banana, etc.
6. Carbohydrates ex. bread, rice, noodles, etc.(Ottoboni and Ottoboni, 2004)

The retention of food quality is required to ensure the use of food with high nutritional values which is important for our health. Thus, preservation methods are the best way to keep food quality and prevent them from deterioration. Nowadays, various types of preservation methods are available that can be used to maintain the quality of food

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products for a long period of time, either by using the conventional or modern preservation technology methods. Some of these preservation methods use additional food preservatives which can be classified into artificial and natural preservatives category.

Many of the synthetic food and cosmetic additives are considered to be safe, but some of them were found to be carcinogenic and very toxic and it is better to limit their use. In general all synthetic chemical additives and preservatives should be avoided, because many of them have not been properly tested (Sabir, 2016).

Ideal Properties of Preservatives:

1. It should not be irritant.
2. To maintain product consistency.
3. To maintain palatability and wholesomeness.
4. It should not be toxic.
5. It should be stable (physically and chemically).
6. It should be compatible with all other ingredients
7. It should be act as good antimicrobial agent
8. It should be potent in action.
9. It should have higher shelf life (Hamid et al., 2012).

Function of Preservatives:

1. To increase or maintain nutritional value of food.
2. To enhance quality and to reduce wastage.
3. To enhance consumer acceptability
4. They inhibit the growth of microbes.
5. They increase reasonably shelf life of processed foods.
6. Some of the commonly used preservatives such as nitrate, and salt – have been used for centuries in processed meats and wine(Mirza et al, 2017).

Classification of Preservatives:

There are two main classes of preservatives:

I. Class I: in this class included those food preservatives which are obtained from nature for example salt, sugar, vinegar, spices, honey, edible oils etc.

II. Class II: in this class included those food preservatives which are chemical, semi synthetic or synthetic in nature such as benzoates, sorbates, nitrites and nitrates of potassium, sulfites, glutamates, glycerides etc. (Anand and Sati, 2013).

Human and animals those consuming or using foods or pharmaceuticals containing more than one preservative is at high risk of exposure to multiple chemicals. Chemically preservatives are categorized as antimicrobial, antioxidant, and antienzymatics.

Antimicrobials: They can destroy or impede the growth of bacteria, yeast and molds, e.g. nitrites and nitrates prevent

Table 1. Codes assigned by Commission of European Union for various preservatives (Anand and Sati, 2013)

E-Number	Name of Preservative	E-Number	Name of Preservative
E 200	Sorbic acid	E 227	Calcium hydrogen sulphite
E 202	Potassium sorbate	E 228	Potassium hydrogen sulphite
E 203	Calcium sorbate	E 230	Biphenyl, diphenyl
E 210	Benzoic acid	E 231	Orthophenyl phenol
E 211	Sodium benzoate	E 232	Sodium orthophenyl phenol
E 212	Potassium benzoate	E 233	Thiabendazole
E 213	Calcium benzoate	E 234	Nisin
E 214	Ethyl p-hydroxybenzoate	E 235	Natamycin
E 215	Sodium ethyl p- hydroxybenzoate	E 239	Hexamethylene tetramine
E 216	Propyl p-hydroxybenzoate	E 242	Dimethyl dicarbonate
E 217	Sodiumpropyl p-hydroxybenzoate	E 249	Potassium nitrite
E 218	Methyl p-hydroxybenzoate	E 250	Sodium nitrite
E 219	Sodium methyl p-hydroxybenzoate	E 251	Sodium nitrate
E 220	Sulphur dioxide	E 252	Potassium nitrate
E 221	Sodium sulphite	E 281	Sodium propionate
E 222	Sodium hydrogen sulphite	E 282	Calcium propionate
E 223	Sodium metabisulphite	E 283	Potassium propionate
E 224	Potassium metabisulphite	E 284	Boric acid
E 226	Calcium sulphite	E 285	Sodium tetraborate (borax)
		E 1105	Lysozyme

Table 2. Preservatives with their maximum possible limits and food products where they can be used (Sharif, 2017).

Preservatives	Class	Max possible limit	Products where they are found
Sodium and potassium benzoate, benzoic acid	Antimicrobial	200ppm	Pickles, margarine, fruit juices, jams, cheese, baked goods, snacks
Methyl and propyl paraben	Antimicrobial	0.1%	Baked goods, beverages, dresssings, relishes
Sorbic acid, Sodium, potassium and calcium sorbates	Antimicrobial	200ppm	Dairy products, bakery goods, sweets, syrups, fruit juices, jams, jellies, beverages
Sulfites and sulfur dioxide	Antimicrobial	200-300ppm	Dry fruits and fruits, molasses, fried or frozen potatoes, shrimp and lobster
Propionates	Antimicrobial	0.32%	Bakery products, cheese, fruits
Nitrites and nitrates	Antimicrobial	100-200ppm	Meat products
Propyl gallate	Antioxidant	200ppm	Baked foods, meats
BHA (butylated hydroxy-anisole) and BHT (butylated hydroxytoluene)	Antioxidants	100ppm for meat products, 50ppm for breakfast cereals and potato products	Baked foods and snacks, meats, breakfast cereals, potato products
Tert-butylhydro-quinone (TBHQ)	Antioxidant	100ppm	Baked foods and snacks, meats
Erythorbic acid (iso-ascorbic acid) and citric acid	Antienzymatic	200-350ppm	Soft drinks, juices, wines and cured meats

Table 3. Preservatives used in various formulations(Baudouin et al., 2010)

Category	Products	Preservatives
Oral	Tablets, capsules, suspensions and syrups	Methyl, ethyl, propyl parabens and their combinations, sodium benzoate, benzoic acid, calcium lactate, sorbates of calcium, sodium and potassium, sorbic acid
Parenteral	Small and large volume parenterals including vaccines	Methyl, ethyl, propyl, butyl parabens and their combinations, benzyl alcohol, chlorbutanol, chlorhexidine, thiomersal, formaldehyde
Nasal	Nasal drops, sprays and aerosols	Benzalkonium chloride, phenylcarbinol, potassium sorbate, chlorobutanol, chlorocresol, EDTA
Ophthalmic	Eye drops, ointments and contact lens solutions	Benzalkonium chloride, EDTA, benzoic acid, thiomersal, imidurea, chlorhexidine, polyamino propylbiguanide, sodium perborate, boric acid
Dental	Toothpastes, mouthwashes and gargles	Sodium benzoate, benzoic acid, potassium sorbate, sodium phosphate, triclosan, cetylpyridinium chloride, methyl and ethyl parabens
Dermal	Cream, lotion, ointment, soap, bath gel, hair spray, shampoo and conditioner	Benzalkonium chloride, cetrimide, EDTA, benzoic acid, thiomersal, imidurea, chlorhexidine, chlorocresol, phenyl salicylate
Rectal	Suppositories and enema	Benzyl alcohol, benzoic acid, sodium benzoate, methyl hydroxybenzoate, chlorhexidine gluconate

botulism (food poisoning by bacteria) in meat products. Sulfur dioxide prevents further degradation in fruits, wine and beer. Benzoates and sorbates are anti-fungal agents used in jams, salads, cheese and pickles prevent fungal growth.

Anti-oxidants: These slow or stop the breakdown of fats and oils in food that occurs in the presence of oxygen proceed to rancidity. There are three types of antioxidants:

a) True antioxidants such as Butylated hydroxytoluene (BHT) and Butylated hydroxyanisole (BHA) block chain reactions by reacting with free radicals; they are commonly used in many food formulations as food preservatives for their antioxidant properties.

b) Reducing agents such as ascorbic acid have lower redox potential than the drug or excipients they are protecting.

c) Antioxidant synergists such as Sodium edetate enhance the effects of other antioxidants (Hugo and Russell, 2004).

Anti-enzymatic preservatives: These block the enzymatic processes like ripening occurring in foodstuffs even after harvest, e.g. erythorbic acid and citric acid stop the action of enzyme phenolase that leads to a brown color on the exposed surface of cut fruits (Kulkarni, 2010).

Chemical classification of Preservatives

Acids: eg. Benzoic acid, Sorbic acids, Boric acids

Esters: eg. Methylparaben, Ethylparaben, Propylparaben, Butylparaben, Sodium benzoate, Sodium propionate.

Alcohols: eg. Chlorobutanol, Benzyl alcohol, Phenyl ethyl alcohol.

Phenols: eg. Phenol, Chlorocresol, o-Phenyl phenol.

Mercurial compounds: eg. Thiomersal, Nitromersol, Phenylmercuric nitrate, Phenylmercuric acetate.

Quaternary ammonium compounds: eg. Benzalkonium chloride, Cetyl pyridinium chloride (Mirza et al., 2017).

Classification based on source

Natural Preservatives: These drugs are obtained by natural sources from plant, mineral sources, animal etc. Eg.

Neem Oil, sodium chloride, Lemon, Honey.

Artificial Preservatives: These preservative are produced by human through chemical synthesis active against various micro-organisms in small concentration. Eg. Benzoates Sodium benzoate Sorbates, propionets, nitrites (Smith, 2011).

The commission of the European Union assigns E-numbers to an additive after clearance by Scientific Committee on Food (SCF), which is responsible for the safety evaluation of food additives. E numbers are the code for chemicals which are approved for use in the European union and Switezerland, and are adopted by the food industry worldwide. The range of E-numbers assigned to the class of "Preservatives" are 200 to 299. E-1105, lysozyme, is also included in the list of approved preservatives (Inetianbor et al., 2015).

Food preservation methods

1. **Drying:** One of the oldest methods of food preservation is by drying, which reduces water activity sufficiently to prevent or delay bacterial growth. Drying also reduces weight.
2. **Pickling:** Pickling is the process of preserving food by anaerobic fermentation. The resulting food is called a pickle. This procedure gives the food a salty or sour taste. Typical pickling agents include brine, vinegar, alcohol, and vegetable oil. Another distinguishing characteristic is a pH less than 4.6, which is sufficient to kill most bacteria. Pickling can preserve perishable foods for months (Sharif et al., 2017).
3. **Canning** is an important, safe method for preserving food if practiced properly. Canning involves cooking food, sealing it in sterile cans or jars, and boiling the containers to kill or weaken any remaining bacteria as a form of sterilization.
4. **Freezing:** Refrigeration and freezing are probably the most popular forms of food preservation in use today. In the case of refrigeration, the idea is to slow bacterial action to a crawl so that it takes food much longer (perhaps a week or two, rather than half a day) to spoil (Leistner, 2000; Wiley, 1994).
5. **Jellying:** Food may be preserved by cooking in a material that solidifies to form a gel. Such materials include gelatine, agar, maize flour and arrowroot flour.
6. **Vacuum packing:** Vacuum-packing stores food generally in an air-tight bag or bottle. The vacuum environment strips bacteria of oxygen needed for survival so that slowing spoiling. Air can impair the food, which causes the food to rust, promote growth of bacteria or lost property. This technique is very appropriate for foods that travel long distances, this method can keep for weeks or even months if refrigerated (Leistner, 1992).
7. **Water bath:** In this technique food keep in a glass bottle which is full of water tightly closed. Then the bottle is placed in a pot with enough water to cover the jar. Boil for 50 minutes and off. Allow the flask inside the container until the water cools completely, remove it before cause a sudden temperature change that could make the bottle explode. With this technique, the food can last for months or even over a year (Lado and Yousef, 2002).

Health hazards caused by artificial Preservatives

Artificial preservatives are mostly considered safe, but several have negative and Carciogenic, and toxic threatening side effects.

Sulfites are common preservatives used in various fruits, may have side effects in form of headaches, palpitations, allergic reactions, asthma, cancer etc.

- Nitrates and Nitrites: sodium nitrite is a preservative used in meats, hams, sausages, hot dogs, and bacon to prevent food poisoning. It can prevent the growth of bacteria that can cause botulism, but sodium nitrite can react with proteins, or when it cooks at high heats, to form N-nitrosamines it can be carcinogenic. The nitrate binds to hemoglobin (the compound which carries oxygen in blood to tissues in the body), and results in chemically-altered hemoglobin (methemoglobin) that impairs oxygen delivery to tissues, resulting in the blue color of the skin.
- Benzoates can trigger the allergies such as skin rashes and asthma as well as believed to be causing brain damage (Sanjay Sharma, 2015).
- Caffeine is a colorant and flavorant that has diuretic, stimulant properties. It can cause nervousness, heart palpitations and occasionally heart defects.
- Saccharin causes toxic reactions and allergic response, affecting skin, gastrointestinal tract and heart. It may also cause tumors and bladder cancer. These additives are used as curing agents in meat products but get converted into nitrous acid when used and suspected of causing cancer of stomach. Proteins in the stomach react with nitrites and produce nitrosamines, which are carcinogenic. It is reported that there is a substantial link between increased levels of nitrates in food and increased deaths from Alzheimer's, Parkinson's and Type 2 diabetes.
- Benzoates used as a antimicrobial preservatives in foods, and have been suspected to cause allergies, asthma, erythema.
- Sorbates/sorbic acid are added to foods as

antimicrobial preservatives. Reactions to sorbates are rare, but have included reports of urticaria and contact dermatitis.

- Headache, sweating, redness of skin, nausea and weakness can occur after consumption of food having monosodium glutamate (MSG).
- In pregnant women use of these hazardous preservatives may adversely affect fetal brain development. Formaldehyde, hydantoin, diazolidinyl urea and imidazolidinyl urea are all potent irritant which can cause irritation on skin, eye and lung. High levels of exposure to these toxins can cause DNA damage of sperm (Vega et al., 1997).

Researchers claimed that the food additives used in hundreds of children's foods and drinks can cause temper tantrums and disruptive behavior. When nuclear radiation used for the purpose of food preservation does not make foods radioactive, but they may cause changes in food color or texture. Preservative-induced side effects are often very difficult to identify because they mostly occur in a late or non specific manner. Therefore, care should be taken to avoid the long-term use of preservatives (Baudouin et al., 2010).

Natural preservatives: Better Alternatives

However, in recent years, consumers are demanding complete substitution of chemically synthesized preservatives due to their toxic adverse effects on health due to this fact has lead to an increasing interest in the development of more "natural" alternatives in order to increase food shelf-life and safety. In recent decades, special attention has been focused on spices and aromatic vegetables which are commonly employed as food ingredients as well as in form of food preservatives. In spite of the fact that they are usually used as flavouring agents to enhance the aroma or the taste of a great variety of foods, it is also well known that spices act as a natural antioxidant and having antimicrobial compounds.

1. **Onion:** It is one of the most widely distributed vegetables and have several beneficial health effects. Onions are a rich source of dietary flavonoids. They are mainly represented by the flavonols, quercetin and kaempferol, commonly present as glycosilated forms. Therefore, onions have been proposed as a good source of natural preservatives it enhance stability and preservation of food as well as increase their nutriceutical values. The antimicrobial activity of onion due to the presence of thiosulfinates and other volatile organic compounds. They are the parts mainly responsible for the onion's characteristic aroma, taste and lachrymatory effect, but they are also of great interest on account of their antibacterial, antifungal and antiviral properties (Strickley et al., 2008).
2. **Oil:** When food comes into contact with air, it get oxidizes and starts to go bad. Oil slows down this oxidation process and keeps microorganisms away from coming into contact with the food.
3. **Salt:** The antimicrobial activity of salt is related to its ability to reduce the water activity thereby influencing microbial growth. It has the following properties like It produces an osmotic effect, limits oxygen solubility, changes pH, their Sodium and chloride ions are toxic.
4. **Vitamine E**: an anti-oxidant widely used in cosmetics, pharmaceuticals. It is found most abundantly in wheat germ oil, sunflower, and safflower oils.
5. **Sugar:** Like salt, sugar also preserves food by absorbing the excess water and preventing microorganism growth. This is why jams, jellies and other fruits preserves don't go bad even after the jar has been opened.
6. **Grape fruit extract:** Also known as citrus seed extract, is a liquid derived from the seeds, pulp and white membranes of grapefruit *Citrus paradise*. It is a natural broad spectrum preservative used to kill or inhibit the growth of bacteria, viruses, fungi and other microbes. It should be used in conjunction with others broad spectrum preservatives to be effective. It can be used in quantities of up to 1% of the recipe (Hugo and Russell, 2004),
7. **Acids:** Food acids are added to make flavor and also act as preservatives and as a antioxidant. Common food acids like vinegar, citric acid, tartaric acid, malic acid, fumaric acid, and lactic acid sorbic acid. These molecules inhibit the growth of bacterial and fungal cells and sorbic acid is also inhibiting the germination and outgrowth of bacterial spores.
8. **Cloves:** (*Carophyllus aromaticus*) medicinal herbs are natural food preservatives and are used as flavor and seasoning for cakes, bread, pies, as well as meat and fish. They are natural medicinal herbs that are taken from an evergreen tree and they are from the Myrtaceae family. They possess antiseptic, expectorant, anesthetic; antihistamine as well as emmenogogue properties. They can act as antimicrobial agents by killing microbes.
9. **Cinnamon:** Cinnamon medicinal herb contains essential oil that is anti-fungal and antibacterial. The main parts used as herbal medicine are the bark, leaves, stems, flowers and the volatile oil. The aromatic odor is so strong that it will make you feel cozy and warm. It is an ancient spice and the medicinal properties are aromatic, germicide, stomachic, anti-clotting, astringent, carminative, digestive and antispasmodic. It is also used for uterine hemorrhages and as a sex stimulant.

10. **Guar Gum** – It is made from seeds of the guar plant *Cyamopsis tetragonoloba*, this plant grown in India, is used in pharmaceutical preparations and food products such as processed cheese, ice cream, jelly and dressings as a stabilizer (Russell et al., 1999).
11. **Rosemary extract:** It is obtained from *Rosmarinus officinalis*, has anti-oxidantproperty so that it slows down oxidation of natural materials. It also improve the shelf life and heat stability of omega 3-rich oils, which are susceptible to rancidity.
12. **Niacin** is an antimicrobial polypeptide produced by some strains of *Lactococcus lactis,* Nisin-like substances are widely produces by lactic acid bacteria. These inhibitory substances are known as becteriocins. It forms pore in cytoplasmic membrane of bacteria resulting in depletion of protonmotive force and loss of cellular ions, amino acids, and ATP.
13. **Chitosan** is used with edible coating and films, which help to reduce the water vapour content, prevent oxygen transmission and extending the shelf life of fruits. Thus, this will prevent deterioration of food (Ahmed, 2013).
14. **Lysozyme** present in eggs and milk can be used as antimicrobial agent and it has being recognized as safe. It is used as a preservative for poultry product, meat, fruits etc.
15. **Lactoferrin** is one of natural antimicrobial agents it is found in mammalian secretion like saliva, milk, tears, etc. Lactoferrin decrease the number of iron which is present in the surrounding environment, this condition will hinder the development of the bacteria cell (Aneja et al., 2013).

Determination of preservatives in food by different analytical methods:

Many analytical methods have been reported for the determination of preservatives. The proposed methods were used for detection of different preservatives in various food stuffs by different analytical techniques like Uv-Visible, Calorimetry, HPLC, GC, LCMS and Electrophoresis (Juneja et al., 2012; Table 4).

Table 4. Determination of Preservatives in food by different analytical methods

Preservatives	Method
Benzoic Acid and Sorbic Acid	Overlapped HPLC –PDA
odium Benzoate and Potassium Benzoate	HPLC
Benzoic Acid	UV Spectrophotometry
Sorbic Acid	UV Spectrophotometry
Sodium, Potassium Salts of Nitrates And Nitrites	Colorimetry
BHT And BHA	HPLC
Methgyl Paraben Propyl Paraben	HPLC

Discussion and conclusion

Those Foods which are preserved with the use of natural additives have become more popular due to greater consumer awareness and concern regarding harmful effects of synthetic chemical additives. This has led researchers and food processors to look more and more on natural Preservatives .If use of food additives is must, because of their advantages, then they should be the natural ones which have minimal effects and those that are generally recognized as safe. As we have seen that as compared to synthetic preservatives which are used in preserving foods, cosmetics, etc, natural preservatives has lesser side effects, easily available, and economical. So we can easily use it. Natural preservatives not only reduce the bacterial growth but also enhance the shelf life of food products, pharmaceuticals and cosmetics in which it is added. It also allows them to remain fresh or maintain its consistency for a long span of time and causes no toxic effect. Artificial preservatives are chemical substances may produce health hazards. Awareness about the harmful effects of these chemicals in food, cosmetics and pharmaceuticals is increasing nowadays. Natural preservatives offer greater advantages over their artificial counterparts due to their non-toxic nature along with a wide range of health benefits.

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