__Review Article__

Role of natural preservatives and their effect on human health

Abstract

In our daily life, all living creatures need some amount of food. We also know that the food has a limited period to keep it safe and fresh. To keep the food material safe to consume for a more extended period, its taste, odor, and quality, we have to add some preservative to our food material. There are two types of preservative present in now a day in market. Nature preservative i.e., Rosemary extract, Garlic, Lemon, Plant extract etc. are safe to consume, but its shelf life is less than the synthetic one. Synthetic preservative is also cost-effective and having long shelf life, so many manufactures are using sodium benzoate, Potassium sorbate, Sorbic acid, and Benzoic etc. This evaluation focuses on natural preservatives which is used for increasing shelf-life, their mechanisms of action and its uses forms (i.e., power, fruit, essential oils, extract) to food has been conserved. The amounts of phenolic compound in herbs and spices play an essential role on significant part in their antibacterial properties, However, it is also dependent on a variety of intrinsic and extrinsic variables that must be identified prior to using herbs and spices as additions. As a result, the current review provides a thorough overview of the numerous antioxidant and antimicrobial groups, focusing on their properties, mechanism of action, and application in the food industry.

Keywords: -Natural preservative, Antioxidants effects, Shelf life, Spices, Herbs.

Introduction

Preservatives are substances added to food, pharmaceuticals, cosmetics, and industrial products to keep them from deteriorating and extend their shelf lives. The effects of light, air, humidity, and bacteria all contribute to degradation. Preservatives typically have chelating, antibacterial, and antioxidant properties. Depending on where they come from, preservatives might be labeled as natural or artificial. The growing awareness of the detrimental effects of synthetic preservatives on health has increased the value of natural preservatives. Plants are one of the most important natural preservatives [1]. Some natural Preservative are as: Vinegar, Salt, Spices, Edible oil, honey, Sugar, etc.The widespread issue plaguing the food supply chain is the substantial risk of contamination by harmful microorganisms responsible for both pathogenic infections as well as waste. Dairy products, in particular, are highly susceptible to contamination. Multiple sources of contamination have been identified in the dairy business, particularly in smaller-scale farm production. These sources include the utilization of unpasteurized milk, the hygiene of the dairy processing environment, and, in certain instances, even the use of vegetable coagulants [2]. To generate energy, promote growth, and maintain excellent health, humans and animals ingest food in the form of raw, processed, or specially designed components. Most cases in some instances, there are no restrictions on eating. Nevertheless, excessive use of some kinds of foods high in fat, sugar, and salt could be dangerous to health [3]. The food sector is extremely concerned about microbial food deterioration. According to estimates, microbial activity causes up to 25% of all food produced to be wasted after harvest. Although the development of spoilage microbiota in food poses no threat to human health, it has a detrimental effect on the finished products' overall quality, shelf life, and textural attributes. It also influences customer preferences and causes considerable economic losses. Thus, for the current worldwide food production, preventing or inhibiting microbial growth in foods is of highest importance [4].Preservatives are used to inhibit the growth of microorganisms that might cause food spoilage and food poisoning; and to extend the shelf-life of items so that they can be disseminated and sold to consumers with a longer shelf-life. Preservatives and antibacterial agents are critical components of today's food supply. The growing demand for convenience meals, along with the relatively extended shelf life of processed foods, necessitates the usage of chemical food preservatives. Some regularly used preservatives, such as nitrate and salt, have been employed in processed meats and wine for ages. As a result, it works well as an antibacterial in high-acid meals, fruit drinks, cider, carbonated beverages, and pickles[5].

Natural preservatives are commonly employed in the food industry to inhibit the growth of undesirable bacteria. Plant antimicrobials can be incorporated into a product's formulation, applied to the surface of food, or incorporated into packaging material. It does, however, have a distinct mode of action. Plant-based essential oils, animal-derived enzymes, microbial-derived bacteriocins, organic acids, and naturally occurring polymers [chitosan] have all been used in the food industry [6]. The scientific community could explore novel chemical techniques to research and develop new compounds, building upon existing natural molecules. By modifying these familiar molecules, there is potential to enhance their performance, achieving dual benefits such as improved coloring and preservation properties. This avenue of research offers a promising way to overcome challenges and capitalize on the utilization of these additive compounds within the food industry [7].

Polyphenols are well-known for their antibacterial and antioxidant properties. Their bioactivity originates from their ability to carry out a number of critical functions, including:

1. Polyphenols have the ability to neutralize and eliminate free radicals and reactive oxygen/nitrogen species (ROS/RNS), which are unstable molecules that can cause cellular harm.

2. Reducing Oxidized Intermediates: Polyphenols can help reduce and stabilize oxidized intermediates, preventing the harmful effects of oxidative stress on cells and tissues.

3. Inducing Metal Chelation: Some polyphenols can bind to metal ions, a process known as chelation. This can be beneficial in preventing metal-catalyzed oxidative reactions that generate free radicals.

4. Inhibiting Enzymes Responsible for Free Radical Formation: Polyphenols can inhibit enzymes involved in the formation of free radicals, further reducing oxidative damage.

Overall, polyphenols are valuable substances for promoting health and avoiding disease by countering oxidative stress and microbial risks in the body [8].

In recent years, there has been an increase in consumer demand for higher-quality, preservative-free, and less processed foods with a longer shelf life. This tendency has fueled interest in employing natural substances, particularly preservatives produced from herbs and plant products, as alternatives to synthetic chemical compounds currently in use [9].

CHEMISTRY AND CLASSIFICATION OF POLYPHENOLS

Antimicrobials produced from plants hold significant promise as natural preservatives due to their reputation for safety, health benefits, and the added value they bring through their bioactive and nutritional properties. These natural preservatives have a rich history of traditional consumption by humans over decades.

Polyphenols are secondary metabolites generated from either the shikimate or polyketide pathways in plants, are particularly noteworthy. They exhibit a wide range of variations among different plant species and serve multiple essential functions, including:

1. Pigment Formation: Polyphenols play a vital role in the formation of pigments, contributing to the coloration of plants.

2. Resistance to Environmental Stresses: They help plants endure environmental challenges by providing defense mechanisms against diseases and UV radiation protection.

3. Chemical Messengers: Polyphenols also act as chemical messengers within plants, regulating various physiological processes.

These compounds are often made up of one or more aromatic rings that have hydroxyl groups connected to them. Their various chemical structures and functions make polyphenols valuable for various applications, including as natural preservatives in food products [10].

Methanolic and ethyl acetate root extracts had 85.18 and 62.96% activity against E. coli, respectively. Furthermore, methanolic (84.61%), chloroform (61.53%), and ethyl acetate root extracts (69.23%) significantly inhibited S. aureus. Methanolic leaf extracts had high activity against A. bumanni (78.26%), E. coli (77.78%), and S. aureus (73.07%). They also discovered that methanolic bark extracts had modest effectiveness against A. bumanni (65.21%) and E. coli (62.96%). Furthermore, the extracts demonstrated strong antioxidant activity, with EC50 values ranging from 157.82 to 361.61g/ml. The antibacterial effects of Azadirachta indica (A. indica) phenolic extracts were investigated on the shelf-life stability of uncooked beef patties stored at 4°C for 11 days [11].

Plants high in bioactive chemicals can be used as preservatives and antioxidants to naturally protect and enhance the quality of various products (shown in table 1). These bioactive-rich plants contain natural substances that can help prevent spoilage and oxidation. Instead of relying on synthetic chemicals, which can have health and environmental concerns, bioactive-rich plants offer a more sustainable and potentially healthier approach to preserving and safeguarding products.

In table 1, there is a list of plant to use as natural preservative and also mentioned the used plant part, amount which is added, the effect and its major component in extending the shelf-life of a food product.

Table 1: Use of bioactive-rich plants as preservatives and antioxidants.

Plant	Part Used	Amount added in Food (%)	Effect	Major Component	Reference
Curry	Leaf	2.5	Lower level of TBARS	Cinnamic, chlorogenic, ferulic, vanillic acids, Tannic, gallic, and	[12]

				caffeic	
Black Pepper	Fruit	1	Inhibition of lipid oxidation	Capsanthin and capsorubin	[13]
Black Cumin	Seed	>0.5	Inhibited of lipid oxidation	Anthocyanins	[14]
Lotus	Leaf	6	Lower level of TBARS	Citric acid, tannin, malic acid, succinic acid, and tartaric acid	[15]
Garlic	Bulbs	1.5	Reduction in plaque, decrease in LDL level, increase HDL, Decrease pressure	Allicin	[16]
Ginger	Rhizome	1.5	Lower leve	Gingerol and shogaols	[17]
Amla	Fruit, seed	1	Inhibition of lipid oxidation	Quercetin, gallic acid, kaempferol, and, ellagic acid	[18]
Clove	Flower buds	1	Inhibits Gram-negative and Gram-positive bacteria and yeast	Eugenol	[19]
Broccoli	Leaf	>0.1	Lower level of TBARS	Phenolic acids and flavonoids	[20]
Lemon	Fruit	0.001	E. coli O157:H7 was reduced by 1.7 logs	Limonene, Sabinene Citronella, linalool	[21]
Thyme	Leaves	0.8-1.2	From day six until the end of storage, the viable count was reduced to less than 2 logs (CFU/g)	Thymol, terpinene, p-cymene, carvacrol, and linalool	[22]
Turmeric	Rhizome	3.5	Inhibition of lipid oxidation	Curcumin	[23]

Factors Influencing Postharvest Spoilage by: Moisture Activity

Moisture activity, abbreviated "aw," is a measure of the ratio between a food's equilibrium water vapor pressure (Pw, in kilopascals, kPa) and the saturated vapor pressure of pure water (Pwo, in kPa) at the same temperature. This metric is an important measure of how water is coupled to the food, showing the product's moisture availability. It is influenced by a variety of factors, including:

1. Lipid Oxidation: The presence of lipids in the food can influence moisture activity, as interactions between water and lipids can affect the food's moisture-holding capacity.

2. Microbial Growth: Microorganisms require water to grow and proliferate. Moisture activity plays a significant role in determining whether the water content is sufficient to support microbial growth or if it inhibits it.

3. Enzymatic and Non-enzymatic Activity: Moisture activity can impact enzymatic reactions and other chemical processes within the food, as the availability of water can influence the rate and extent of these reactions.

4. Changes in Texture Profile: The moisture content and distribution within a food product can affect its texture and consistency. Moisture activity is a key factor in understanding and controlling these textural attributes.

Overall, moisture activity is a critical parameter in food science and technology as it helps assess the stability, safety, and quality of food products, particularly with regard to water-related reactions and microbial growth [24].

Factors Influencing Postharvest Spoilage by: Oxidation Activity

Water, fat, protein, and carbs make up the primary building blocks of food resources produced from plants and animals. Fats and oils are the most ubiquitous lipid compounds in nature. Oil is liquid at room temperature while fat is solid, indicating a difference in its physical characteristics and consistency. The melting point of lipids (polyunsaturated fatty acids, PUFA) is affected by the amount of double bonds, the length of the carbon chain, and whether the unsaturated fatty acids are cis or trans [25].

Factors Influencing Postharvest Spoilage by: Antioxidants

There are numerous synthetic antioxidant preservatives, such as butylated hydroxyl toluene (BHT), butylated hydroxy anisole (BHA), tertbutyl hydro-quinone (TBHQ), and propyl gallate (PG), are commonly used in meat products to avoid lipid oxidation deterioration. The use of antioxidants in food is governed by international standards or national regulatory regulations. The use of synthetic antioxidants is generally restricted due to the possibility of cancer-causing effects [26].

PLANT-BASED PRESERVATIVES

Natural herbs and spices have preservation properties based on the kind, nature, and concentration of the organism. Spices and herbs have volatile compounds in them. These compounds are extracted using a variety of techniques and utilized to make preservatives. As self-defense mechanisms, the substances present in herbs and spices help the plant defend itself against infectious organisms. Plant oils and extracts have long been used as food preservatives and medicinal compounds in medicine, according to sources [27].

Preservative classification:

There are primarily two groups of preservatives:

I. Class I: The food preservatives derived from nature, such as: sugar, salt, vinegar, honey, spices, edible oils, etc., were included in this class.

II. Class II:Benzoates, sorbates, potassium nitrites and nitrates, sulfites, glutamates, and glycerides are examples of chemical, semi-synthetic, and synthetic food preservatives.

Humans and animals who consume or use foods or pharmaceuticals containing more than one preservative face a significant risk of chemical exposure. Chemical preservatives are classified into three types: antimicrobial, antioxidant, and anti-enzymatic [28].

Food preservatives are classified into two classes: Class I and Class II. As stated in Figure 1, natural preservatives are classed as Class I, whereas synthetic or chemical preservatives are designated as Class II.

However, only one type of Class II preservative should be used in a specific food product because individuals who ingest too much of them, such as sulfites, benzoates, sorbates, and so on, may be harmed. The classification of both types of preservatives is depicted in Figure 1.

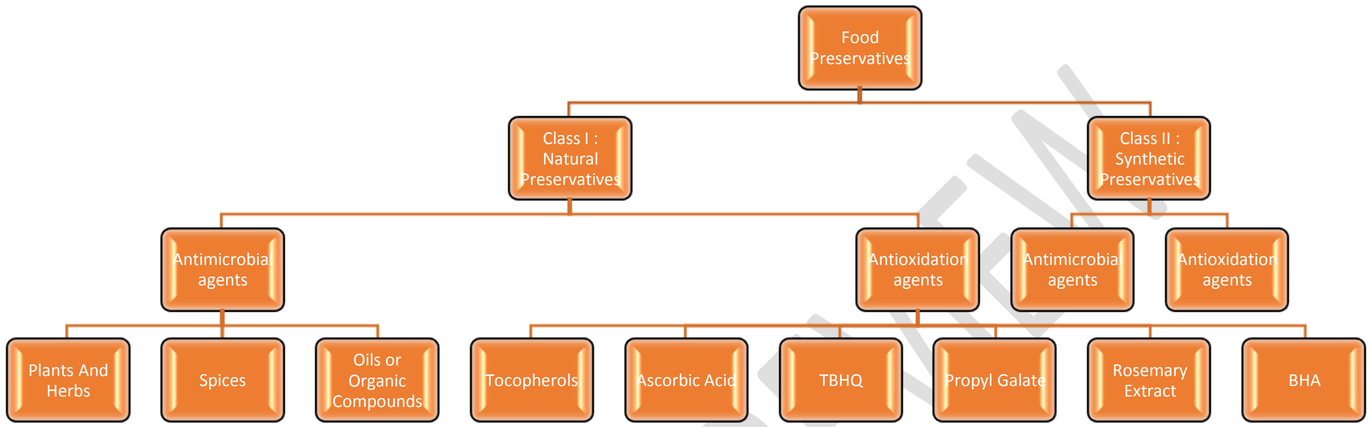

Fig 1: Categories of food preservatives [29].

Function of Preservatives

1. Enhancement of nutritional value of food.

Traditional food preservation methods are inefficient in preventing the spread of food-borne pathogens. The increased desire for chemical-free food has cleared the path for antimicrobials to be used in the food industry. Antimicrobials are a revolutionary technology utilized by the food industry to increase food shelf life while also addressing quality and safety problems [30].

2. To improve quality and lower waste.

Food preservation is the treatment and handling of food to prevent or considerably slow deterioration (loss of quality, edibility, or nutritious value) caused or accelerated by microorganisms. Some approaches, on the other hand, use harmless bacteria, yeasts, or fungi to add specific attributes and preserve food (e.g., cheese, wine). It is critical to maintain or create nutritional value, texture, and flavor in order to maintain its worth as a food. This is culturally dependant, as what qualifies as human nourishment in one society may not qualify in another. Preventing the growth of bacteria, fungi, and other microorganisms, as well as slowing the oxidation of fats that causes rancidity, are common methods of preservation.It also covers methods that are used to prevent natural aging and discoloration that can occur during food preparation, such as the enzymatic browning reaction that occurs when apples are chopped[31].

3. To increase consumer acceptance.

The safety of natural substances is being questioned, and customers are increasingly requesting them. As a result of their inherent qualities, spices are a powerful tool for the food sector. Spices do have antioxidant properties, owing to the presence of phenolic chemicals. They have antioxidant properties because they scavenge free radicals, chelate transition metals, quench singlet oxygen, and increase the activity of antioxidant enzymes. At 37 and 80 degrees Celsius, the CO2 extract of ginger demonstrated in vitro efficacy comparable to that of BHT in preventing lipid peroxidation. Furthermore, in a model mixture replicating a heated potato matrix (180C for 20 minutes), pimento and black pepper extracts reduced acrylamide production by up to 75 and 50%, respectively[32].

4. Inhibition of microbial growth.

Natural food preservatives are completely safe. Natural food preservatives are usually sourced from plants, animals, or microorganisms. Natural preservatives are generally employed in the food industry to prevent the growth of undesirable bacteria. Plant antimicrobials can be used in product formulation, as a coating on the surface of meals, or as a component of packaging material. Its manner of action, however, is distinct. Plant-derived essential oils, animal-derived enzymes, microbe-derived bacteriocins, organic acids, and naturally occurring polymers (chitosan) have all been used in the food sector [33].

5. They help to extend the shelf life of processed goods.

The current study aims to increase the shelf life of fresh prepared foods by employing plant-based natural preservatives. This study makes use of lemon juice, basil leaf extract, mint leaf extract, and lemongrass essential oil. The goal is to compare the various natural preservatives based on enzymatic and microbiological inhibition as well as sensory acceptance. The formulation of a natural preservative was optimized using a multi-objective genetic algorithm. Furthermore, principal component analysis is used to visualize changes in several quality metrics after preservative-added storage[34].

Examples of some preservatives added for food preservation

Salt

Salt acts as a preservative because it can attract water, and as a result, the material's water activity reduces, preventing microbe growth and reproduction. Salt preferentially inhibits polluting bacteria such as spores and proteolytic microbes [35].Salting food can also produce osmotic stress in microbial cells, which causes the cell to lose water and eventually results in cell death or reduced growth [36].Furthermore, salt may limit the solubility of oxygen for some microorganisms, interfere with biological enzymes, or make cells work harder to discharge sodium ions from the cell, all of which can inhibit growth [37].Salting or curing eliminates moisture from meat via osmosis. Curing meat involves the use of salt, sugar, or a mixture of the two. Furthermore, nitrates and nitrites are widely used to cure meat, giving it a unique pink tint and limiting the growth of Clostridium botulinum [38].

Sugar

Fruit and some vegetable products use sugar to enhance flavor and extend shelf life. Whole and cut-in-half fruit, relishes, pickles, jams, and jellies are examples of these items. Except for vegetables, sweeteners are regarded an essential element in the majority of canning products. They operate as preservatives, preserving the desired appearance, flavor, color, and body of the items. These qualities will change if the type and amount of sugar in standardized preservation recipes are changed. Sugar (sucrose) and corn syrup are the two main sweeteners used in canning. Saccharin, a noncaloric sweetener, is found in dietetic meals. Noncaloric sweeteners aspartame and acesulfame K are allowed for usage in a restricted variety of foods [39].

At 10% concentrations, the relative sweetness of invert sugar compared to sucrose. In terms of sweetness, sucrose is sweeter in concentrations less than 10%, while invert is sweeter at concentrations greater than 10%. However, due to the sweetness-enhancing property of sucrose, a partially inverted sucrose solution will be sweeter than a wholly inverted solution. The sweetness of the different sugars varies. Sucrose sweetness is instantly sensed and achieves a maximum intensity, but dextrose sweetness stimulates the taste organs more slowly and reaches a maximum intensity later. The fundamental flavor of glucose is sweet, but the secondary flavors are bitter, sour, or tart, whereas secondary flavors are absent in sucrose [40].

Vinegar

In the past, raw ingredients containing starch and sugar were used to make vinegar. In a two-stage fermentation, ethanol is produced first, followed by acetic acid. Traditional vinegar manufacturing requires a longer fermentation period of roughly 30 days, and it serves as a starter culture for vinegar manufacture at commercial platforms, which is finished in 24 hours. Traditional vinegar is made from apple, coconut, plum, tomato, grape, and potato juices [41].

Wine and beer are the most likely alcoholic beverages that are used to make vinegar when it is diluted. In addition, many additional basic materials, including as rice, sugarcane, and malt, are already present in the system as alternatives to both beer and wine. These materials undergo fermentation processes to produce alcoholic beverages. Before beginning the manufacturing of vinegar, certain treatments are given after the collection of alcoholic liquid, including pasteurization and filtering [42].

Herbs and fruits with a variety of specialized functions are integrated into the vinegar production method to produce flavor-infused vinegar. Implemented are the herb categories of tarragon, garlic, and basil. Lemon, pomegranate, apple, and cherries are all included [43].Spices can demonstrate antimicrobial effects through two distinct mechanisms: firstly, by impeding the proliferation of spoilage microorganisms, thus aiding in food preservation; and secondly, by limiting or regulating the growth of harmful bacteria and thereby improving food safety [44].

Spices

The phenolic chemicals found in spices give them their antioxidant properties. They exhibit antioxidant properties through scavenging free radicals, chelating transition metals, quenching singlet oxygen, and increasing the activity of antioxidant enzymes [45].Ginger's CO2 extract demonstrated in vitro efficacy that was comparable to BHT's in preventing lipid peroxidation at both 37 and 80 degrees [46].Lipid oxidation is a major cause of food rotting. As a result, the food industry employs antioxidants such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) to prevent spoilage [47].

Customers, on the other hand, are increasingly preferring natural substances, and their safety is questioned. Because of their inherent qualities, spices are a powerful tool for the food sector [48].

Honey

Honey's antimicrobial properties can be divided into peroxide and non-peroxide components. Honey's main antibacterial component is hydrogen peroxide, which is created when the enzyme glucose oxidase, present in the hypopharyngeal glands of honey bees, oxidizes glucose and other monosaccharides [49].Honey is frequently used as a preservative in foods including milk, cheese, and turkey slices. Honey was utilized to improve the shelf life of kununzaki, a Nigerian non-alcoholic beverage, by up to five days at room temperature 25°C [50].

Edible Oils

Essential oils are aromatic and volatile liquids extracted from numerous parts of the plant, including the flowers, roots, bark, leaves, seeds, peel, fruits, wood, and whole plant. Essential oils have been used in gastronomy as spices or herbs, as well as in fragrance, cosmetics, and medicine since antiquity [51].The bulk of essential oils are composed of low-molecular-weight volatile chemical molecules. The ingredients of essential oils can be split into two categories: terpenoids and non-terpenoid hydrocarbons. Terpenoids, which are generated by combining two (monoterpene), three (sesquiterpene), or four (diterpene) isoprene units, and phenylpropanoids (non-terpenoid hydrocarbons) are the two structural families of phenolic chemicals [52].

The effect of an edible gelatin covering containing orange leaf essential oil on the shelf life of chilled pink shrimp. Adding 2% orange leaf essential oil to the gelatin solution increased the shelf life of shrimp by 10 days as compared to uncoated samples [53].Phenolic compounds in EOs have a strong interaction with the lipids in cell membranes, making them more permeable. This causes the cellular structure to be destroyed or disrupted, as well as the release of intracellular chemicals. In the formulation of EO-edible coatings, a number of microbial species and strains were tested [54].Carvacrol, eugenol, and thymol are common phenolic components found in high amounts in EOs with the strongest antibacterial activity against foodborne pathogens. The phenolic chemical family, which has a wide range of structural modifications, is one of the most diverse families of secondary metabolites. Because the hydroxyl (-OH) groups in phenolic compounds can interact with bacterial cell membranes, causing membrane structures to rupture and cellular components to leak, it is thought that these groups have an inhibitory impact [55].

Herbs

Plants and plant materials are rich in bioactive compounds (such as natural antioxidants) that have the potential to improve health, natural antioxidants may be a solution to the problem of preventing lipid oxidation processes. For generations, people have utilized herbs and spices to make food. They are used in a number of recipes to enhance flavor and scent or to extend food shelf life[56].The herb thyme is a raw material used in a variety of food industries and adds flavor and scent to cooked foods (meat, sausages). Thyme is a fragrant shrub that is used as a spice and for therapeutic purposes. Additionally, it gives food scent and functions as a preservative, antioxidant, antifungal, and antibacterial. Oregano, a popular spice, contains essential oils such as thymol and carvacrol [57].

Natural antimicrobia can come from a variety of sources, including plants, animals, bacteria, algae, and fungi. Plant extracts have the advantage of being used by humans for thousands of years. Many plants are employed in traditional medicine, functional foods, nutritional supplements, and the creation of recombinant proteins, in addition to antimicrobial. Their ability to inhibit/control the growth of germs, particularly harmful bacteria, as well as to manage natural deteriorating processes (food preservation), lends them to their role as antimicrobial [58].

Conclusions

The present paper presents that a number of natural preservatives developed from different sources with different preservative properties. Preservatives are simply an option for extending the life of the product by blocking the growth of spoilage bacteria and preventing oxidative reactions. We can get the taste of non-seasonal fruit and vegetable at every season. If possible, we should only use natural preservatives. Natural preservatives may have a smaller environmental impact than synthetic alternatives because they are frequently produced from renewable plant sources. Many consumers prefer products with natural preservatives, reflecting an increasing demand for less processed and more natural foods. Herbs and spices, for example, are natural preservatives that can improve the flavor and general quality of food goods. Natural preservatives decrease the need for synthetic chemical additives, which some consumers may be concerned about due to potential health hazards and allergies. Many natural preservatives come from plants and have a long history of being used safely in traditional cuisines. Using them can give healthier and more natural alternatives to synthetic preservatives for consumers.

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