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Spices and Herbs as Food Preservatives

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Abstract

The importance of spices and herbs has been widely recognised for a long time. Their potential as a natural preservative has gained importance due to the ever-increasing consumer health concerns. Spices are mainly used as flavouring agents and their importance in food safety has also been studied worldwide. They exhibit enormous health benefits apart from their role in food preservation. This review aims to correlate all the relevant findings and studies on the use of spices and herbs as natural preservatives and their potential role in extending the shelf life of food products considering the main active compounds present in them.

Keywords: Antimicrobial, Antioxidant, Food Preservation, Natural Preservatives, Spices and Herbs

1. Introduction

Spices are well known for their medicinal benefits. There are more than 100 varieties of spices throughout the world. The market of spices and seasonings has witnessed steady growth in recent years due to an increase in demand for functional foods across the globe. Spices and herbs are linked to both health and prosperity. They have the potential to be used as preservatives in many foods. Asia is the main producer of most of the spices in the world, particularly ginger, cinnamon, pepper, nutmeg and pepper. Although spices such as dried seeds, fruits, roots, bark, and so on have been used for rituals, cosmetics and fragrance, their flavouring, colouring and, particularly, preservation characteristics have found extensive use in both conventional and modern food preparations[1]. Studies have shown that compounds isolated from spices and herbs have various active compounds that aid in various antioxidant and antimicrobial properties.

Fresh foods such as seafood, meat etc. have less shelf life than other food items and are more likely to be linked to various food-borne disease outbreaks caused by various microbes[2]. Processing and preservation of seafood is very important as it is highly perishable. Marination of seafood with spices helps to increase the shelf life to a greater extent. The antimicrobial and antioxidant properties of spices and herbs play an important role in food preservation. Many plants are used in traditional medicine, functional foods, nutritional supplements and the preparation of recombinant proteins in addition to their use as antimicrobials[2].

Owing to the increased usage of spices and herbs in food preservation, their economic value has increased significantly. In 2021-22, India exported 1.53 million tonnes of spices. The export of spices from India increased by 6.62% in September 2022 which reflects the importance of spices around the world[3]. This study provides an overview of the important properties and advantages of the use of spices and herbs as natural preservatives.

2. Importance of Spices and Herbs

Spices are one of the main kitchen ingredients that are found abundantly in Indian households. Even though spices are mainly used as flavourings and colourings in food, they have an ultimate advantage as a food preservative. Many people are unaware of this simple method of food preservation. Compared to any other method of food preservation, the use of spices and herbs is highly beneficial and safe for preserving food. Though all the spices used in our kitchen can be used as preservatives, it is important to be aware of their usage, as different spices are used in different foods for preservation. Apart from food preservation, spices also help in the stimulation of saliva, improve digestion, prevent illness and so on.

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Spices have a variety of qualities that set them apart, including their aroma, but their chemical properties are what allows them to be utilised as food preservatives[4]. According to the U.S. Food and Drug Administration (FDA), spice is an aromatic vegetable substance in the whole, broken or ground form, the significant function of which is seasoning rather than nutrition and from which no portion of any volatile oil or other flavouring principle has been removed[5]. Spices provide several benefits over chemical food preservatives. For home cooking, the use of spices ensures that the food lasts as long as feasible. Active research is being conducted to study the benefits of spices and herbs in food preservation, emphasising the active properties of spices. According to Ayurveda, spices help to maintain the balance of the body[6]. Apart from food preservation and offering health benefits, spices are also used to alter the colour and physical appearance of food[7].

3. Classification of Spices and Herbs

The term spices can be used to include herbs also. The difference between spices and herbs can be described as the dried components of aromatic plants aside from the leaves may be referred to as spices which apply to the entire plant whereas herbs are generally referred to as the dried leaves of the aromatic plants that are used to taste and occasionally colour food. Spices and herbs fall under the class *Angiospermae* based on taxonomic classification. Spices and herbs can be classified into different groups based on the part of the plant from which they are derived, their economic importance, climate, taste and weather. Table 1 shows the classification of spices based on various parameters.

4. Active Compounds in Spices and Herbs

Antioxidant and antimicrobial compounds are the important active compounds present in spices. As a result of the powerful molecules they contain, which have been proven to have antioxidative effects in food, spices are one of the best sources of natural antioxidants[8]. Natural ingredients have been used to prevent food changes, particularly those caused by oxidative reactions and the growth of microorganisms[9]. Through secondary metabolism, plants have the capacity to synthesise several compounds with diverse antibacterial and antioxidant properties, depending on the intricate structural makeup of the constituents. These substances are created naturally by a plant's defence mechanism when activated under stressful circumstances[10]. The use of natural preservatives in food has been widely accepted by consumers who are increasingly looking for natural and healthy products, free of synthetic additives[11]. The antibacterial and antioxidant properties of natural products, such as herbs, spices and essential oils, are variable. They are not consistently discovered in all plants and can differ even within the same species[12].

5. Antioxidant Properties of Spices and Herbs

Spices and herbs are excellent sources of antioxidants for food preservation due to their naturally occurring antioxidant components[8,13]. These are regarded as natural food antioxidants because foods need antioxidants to protect their lipid constituents from degradation[4]. The chemical components in spices, particularly phenolic compounds, are responsible for their antioxidant qualities. There is a linear link between the phenolic concentration of spices and their antioxidant activity. A significant factor in food quality degradation is oxidative rancidity, which produces unfavourable off-flavours and off-odours as well as harmful chemicals[14]. For years, lipid oxidation was slowed down by the use of synthetic antioxidants like Butylatedhydroxytoluene (BHT) and Butylatedhydroxyanisole (BHA). However, recent concerns about the safety of synthetic antioxidants, combined with a growing preference among consumers for natural products, have led to an increase in the demand for natural antioxidants. Flavonoids, phenolic compounds, sulfur-containing compounds, tannins, alkaloids, phenolic diterpenes and vitamins are some of the bioactive components that cause the antioxidant properties of spices[15]. Antioxidant compounds in spices were mainly determined using chromatographic methods. The ability of spices to prevent the formation of free radicals, destroy them, repair oxidative damage and get rid of damaged molecules is what gives them their antioxidant properties[16]. Carlsen *et al.*,[17] studied the antioxidant properties of around 425 herbs and found that clove has the largest mean antioxidant value followed by cinnamon, oregano, rosemary, thyme and so

Table 1. Classification of spices

Parameters		Spice
Plant Part	Seed	Cumin, Black Cumin, Coriander, Fenugreek, Poppy, Mustard
	Bulb	Onion, Garlic
	Bark	Cinnamon
	Fruit	Chilli, Cardomom, *Kokkam,* Allspice
	Leaf	Curry Leaf, Rosemary
	Rhizome	Turmeric, Ginger
	Pod	Vanilla, Tamarind
	Kernal	Nutmeg
	Floral part	Saffron
	Bud	Clove
	Latex	Asafoetida
	Aril	Maize, *Anardana*
	Berry	Black pepper, Juniper, Allspice
Economic Importance	Major Spices	Small Cardamom, Black Pepper, Chilli Turmeric. Ginger
	Minor Spices	Seed Spices (Coriander, Cumin, Celery, Fennel, Mustard)
		Bulbous Spices (Garlic, Onion, Leek, Shallot)
		Aromatic Spices (Clove, Cinnamon, Aniseed, Nutmeg)
		Leafy Spices (Tamarind, *Kokkam*, *Anardana*),
		Acidulant tree spices
Climate	Tropical	Ginger, Turmeric, Black pepper, Cinnamon, Galangal, Clove
	Sub-Tropical	Cumin, Fennel, Coriander, Fenugreek, Onion and Garlic
	Temperate	Thymes, Saffron, Savey, Caraway Seed
Origin and Flavour	Aromatic	Cardamon, Aniseed, Cumin, Celery, Coriander, Fenugreek, Cinnamon
	Pungent	Ginger, Chilly, Black Pepper, Mustard
	Phenolic	Clove, Allspice
	Coloured	Turmeric, Paprica, Saffron
Life Cycle	Annual	Coriander, Fennel, Cumin, Fenugreek
	Bienniel	Onion, Parsley
	Perennial	Black pepper, Saffron, Clove, Nutmeg, Cinnamon

on[18]. Table 2 lists the natural spices and herbs with potential antioxidant activity.

5.1 Estimation of Antioxidant Activity of Herbs and Spices

Lipid oxidation proceeds through 3 different stages mainly initiation, propagation and termination. The end products of lipid oxidation lead to off flavours in food. The factors that boost lipid oxidation are the presence of oxygen, heat, light and so on. The mechanisms of action of antioxidants act as an effective way to prevent lipid oxidation[20]. Antioxidants primarily serve as hydrogen donors for the lipid-free radicals created during lipid oxidation, allowing them to reorganise into a stable shape[20]. Antioxidant activity can be measured by using various assays such as Ferric Reducing Antioxidant Power (FRAP), Trolox Equivalent Antioxidant Capacity (TEAC), 2,2- DiPhenyl-1 Picryl Hydrazyl radical (DPPH), 2,2-Azino Bis-3-ethylbenzo Thiazoline-6-Sulphonate (ABTS), Oxygen Radical Absorbance Capacity (ORAC) and Total Phenolic Count (TPC). Among these TPC is the most widely used method for the evaluation of antioxidant activity of spices and herbs[20]. The Schaal oven test, the Oxygen stability index using an oxygen stability

Table 2. Natural spices and herbs with potential antioxidant features[19]

	Name	Features
Spices	Saffron	Antioxidant, Anti-inflammatory, Anticarcinogenic, Antidiabetic, Antilipidemic, Antihypertensive and Cognitive function.
	Curcumin	Anti-inflammatory, Antioxidant, Antibacterial, Antidiabetic, Cognitive function, Anticarcinogenic, Antilipidemic, and Antiobesity.
	Cumin	Anti-inflammatory, Antioxidant, Hypolipidemic, Antidiabetic, Antibacterial, Antimicrobial, Hepatoprotective, Nephroprotective and Neuroprotective.
	Cinnamon	Antioxidant, Anti-inflammatory, Sedative, Antidiabetic, Antimicrobial, Antibacterial, Antifungal, Antilipidemic, and Anticarcinogenic.
	Ginger	Anti-inflammatory, Antioxidant, Neuroprotective, Antinausea, Antiobesity, Antilipidemic and Antimicrobial.
	Black Pepper	Antifungal, Antioxidant, Antimicrobial, Analgesic, Antipyretic, Antidepressant, Anticarcinogenic, Anti-inflammatory, Antiallergic, Antithyroid and Antilipidemic.
	Red Chilli	Antioxidant, Anti-inflammatory, Cerebral perfusion, Anticarcinogenic, Antidiabetic, Antiplatelet, Gastroprotective and Antilipidemic.
Herbs	Rosemary	Anti-inflammatory, Antioxidant, Antimicrobial, Hepatoprotective, Antidiabetic, Antithrombotic, Antiproliferative, Anticarcinogenic, Antihypertensive, Cognitive function and Hypolipidemic.
	Coriander	Anticarcinogenic, Anti-inflammatory, Antiobesity, Hypolipidemic and Antidiabetic.
	Dill	Hypolipidemic and Antidiabetic.
	Bacil	Cerebral Perfusion, Anti-inflammatory, Antihypertensive and Antidiabetic.
	Fennel	Antibacterial, Antioxidant, Anti-inflammatory, Antifungal, Hepatoprotective and Antidiabetic.
	Bay Leaves	Hypolipidemic, Anti-inflammatory and Cerebral perfusion.
	Sage	Antihyperlipidemic, Antidiabetic, Anti-inflammatory and Cognitive function.
	Green Tea	Antioxidant, Anti-inflammatory, Antiobesity and Anticarcinogenic.
	Parsley	Antidiabetic, Antioxidant, Antihypertensive and Anti-inflammatory.
	Garlic	Antioxidant, Immunostimulant, Anti-inflammatory, Antihypertensive, Antidiabetic and Antithrombotic, Antihyperlipidemic, Antiviral, Antifungal, Antibacterial, Neuroprotective and Anticarcinogenic.
	Clove	Antibacterial, Antioxidant, Antifungal, Antiviral, Sedative, Local anaesthetic, Antihypertensive, Anticarcinogenic and Antipyretic.
	Thyme/Oregano	Antioxidant, Antibacterial, Antidiabetic and Anticarcinogenic.

instrument and the Oxygen bomb method are the other popularly employed tests to measure the stability of oil or fat for oxidation. These tests intend to expose the substrate to a high temperature in the presence of extra air or oxygen to cause the oxidation of oils or fats[8].

5.2 Application of Antioxidant Extract from Spices and Herbs in Food

The application of antioxidant extracts in the food industry has been reported in various studies[8,21-23]. Salariya and Habib[21] found that high heat treatment of ginger extract showed 85.25% inhibition of linoleic acid peroxidation at 185^{0}C for 2 hours and thus can be used in frying or thermal processing of foods with sunflower oil. The combined use of curcumin and thyme helps in the prevention of *Listeria monocytogenes* in meat products[19,24]. The ethanolic extract of *Arjuna* bark increased the shelf life of *ghee* when compared to the control sample when stored at 8^{0}C[25]. Zarina and Tan[26] assessed the flavonoid activity towards lipid oxidation in the fish tissue and discovered a decrease in peroxide value which showed the suppression of lipid oxidation in fish treated with pomelo peel. Ginger essential oil along with Uwi starch increased the DPPH scavenging activity of edible films[27]. One of the problems in using herbs and spices as antioxidants is their strong odour and flavour.

To minimise it some suppliers deodorise the antioxidant extracts without affecting the sensory attributes of foods[20].

6. Antimicrobial Properties of Spices and Herbs

Spices and herbs possess a wide variety spectrum of activities against gram-negative and gram-positive bacteria. Antimicrobials are used in food mainly for the preservation and safety of foods. More than 1340 plants have been identified as having specific antimicrobial chemicals and more than 30,000 components have been extracted from plant-oil compounds containing the phenol group and employed in the food business[7]. A growing body of research suggests that natural antimicrobials have a significant potential for use in food, particularly when applied to fresh fruits and vegetables, where they can improve food quality and nutritional value in addition to their potent antifungal effects by oxidatively degrading lipids. The most popular methods for producing plant-based antimicrobials on a commercial scale are Steam Distillation (SD) and Hydro Distillation (HD), although alternative techniques like Supercritical Fluid Extraction (SFE) offer better solubility and faster mass transfer rates. Additionally, altering variables like temperature and pressure results in the extraction of various components when a specific component is needed. Oregano, rosemary, thyme, sage, basil, turmeric, ginger, garlic, nutmeg, clove, mace, savory and fennel are examples of edible, medicinal and herbal spices and herbs that have been effectively utilised on their own or in conjunction with other preservation techniques. They operate as antibacterial agents against a range of gram-positive and gram-negative bacteria, or both and can extend the shelf life of goods. However, the pH, storage temperature, amount of oxygen, concentration of EO and active ingredients all affect their efficacy[7,28].

Crude ethanolic extracts and essential oils from 14 different spices, including cardamom, cinnamon, cloves, coriander, cumin, garlic, ginger, holy basil, kaffir lime leaves and peels, lemongrass, mace, nutmeg, black and white pepper and turmeric, were also shown to have an inhibitory effect against 20 different Salmonella serotypes and five different species of other enterobacteria. The levels of antibacterial activity of the spices under research can be arranged in the following order: Cloves, kaffir lime peels, cumin, cardamom, coriander, nutmeg, mace, ginger, garlic, holy basil and kaffir lime leaves[29]. Yano *et al.*,[30] observed that basil, clove, garlic, marjoram, oregano, rosemary and thyme exhibited antibacterial activities against foodborne pathogen *Vibrio parahaemoliticus*. Table 3 summarises antioxidants and antimicrobials extracted from some natural herbs and spices.

Table 3. Antimicrobials and antioxidants from herbs and spices[31]

Spice and Herbs	Botanical Name	Family	Plant Parts Used	Effective Micro-organism	Chemical Compound Isolated	Antioxidant Isolated
Rosemary	*Rosemarinus officinalis* L.	Lamiaceae	Leaf/ Branch	*Bacillus cereus, Staphylococcus aureus, Vibrio parahaelyticus*	Carnasol, Rosanol, Carnosic acid	Carsonic acid, Carnosol, Rosemarinic acid, Rosemanol
Oregano	*Oreganum vulgare* L.	Lamiaceae	Leaf	*Mycotoxigenic Aspergillus, Salmonella* spp., *Listeria monocytogenes, Vibrio parahaemolyticus, Staphylococcus aureus, Aspergillus niger*	Thymol, Carvacrol	Derivatives of phenolic acids, Tocopherols
Thyme	*Thymus vulgaris* L.	Lamiaceae	Leaf/ Branch	*Vibrio parahaemolyticus, Streptococcus pneumoniae R36A*	Carvacrol, Thymol	Carvacrol, Thymol, P-Cymene, Caryophyllene, Carvone, Borneol
Marjoram	*Origanum majorana*	Lamiaceae	Leaf	*Fusarium* spp., *Alternaria* spp., *Cladosporium* spp.	Monoterpenes	Flavonoids
Allspice	*Pimenta diocia*	Myrtaceae	Fruit	*Micotoxigenic aspergillus, Fusarium* spp., *Alternaria* spp., *Cladosporium* spp.	Eugenol	Pimentol

6.1 Mode of Action of Antimicrobial Extract of Spices

Spices and their essential oil contain many bioactive compounds which can be divided into volatile and non-volatile compounds present in varied amounts. Volatile compounds are mainly responsible for the antimicrobial properties of herbs and spices and can be divided into four different groups, terpens, terpenoids, phenylpropenes and products of degradation (others). Among these, the terpenes have fewer active antimicrobial compounds compared to others. Thus in a nutshell antimicrobial activity of spices and herbs is not only based on the action of one compound but also a synergistic action of one or more compounds present in it[1].

7. Conclusion

Spices and herbs can have an impact on both human infections (food safety) and food spoilage micro-organisms (food preservation) due to the antioxidant, antibacterial and antifungal properties of their natural ingredients. The American Food and Drug Administration (FDA) has designated spices as Generally Recognised As Safe (GRAS), meaning they are made from organic herbs and plants. However, the greatest obstacle to good performance against microbes is the requirement for a large quantity of natural substances. Several spices, including black pepper, clove, nutmeg, turmeric, cumin and cinnamon, among others, have antibacterial and antioxidant characteristics that have sparked research for using them as food preservatives. It is possible to replace chemical-based preservatives with natural-based ones for food preservation because spices used in foods, such as meats, have a high likelihood of success and the potential antioxidant and antimicrobial activity can be compared with the effect of the nitrite-based preservatives which are currently being used since they have no negative health effects and also help in enhancing the shelf life of the food products.

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