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Exploring the Antimicrobial Potential of Cumin, Star Anise and Flaxseed: A Spice-Based Approach to Microbial Threats

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ABSTRACT

Excluding flavouring purposes, spices have been applied for centuries, not only as flavour enhancers, but also by virtue of their medicinal and preservative effects. This review discusses antimicrobial effect of all types of spices, especially cumin, star anise, Flaxseed and others, against various pathogens. The secondary metabolites (cuminaldehyde, cymene and terpenoids) present in these spices exhibit the properties of antibacterial, anti-fungal and antioxidant activity. Numerous investigations have additionally demonstrated the antimicrobial action of these spices using techniques like disk diffusion, a minimum inhibitory concentration, and biofilm inhibition.The employment of these spices as potential antimicrobial could offer a promising replacement to synthetic antibiotics and help mitigate the potential for antibiotic resistance while encouraging a better food supply. In addition, the antioxidant and anti-inflammatory effects of these spices commend their inclusion in the treatment of traditional medicine. This review highlights the importance of investigating the medicinal potential of the spices, and their utility in prevention and treatment of different diseases.

1. Introduction

Since ancient times, spices have been utilized as food additives and flavors. In more recent decades, they have also been used as food preservatives and medicines. Numerous spices, including clove, oregano, thyme, cinnamon, and cumin, have been used to prevent food spoilage or treat infectious disorders because of their demonstrated antibacterial abilities against bacteria and pathogenic and spoiling fungi. Additionally, many spices' secondary metabolites are renowned as antibacterial agents, most of which are widely accepted as safe dietary ingredients with few negative effects [1]. Due to their antibacterial qualities, spices including flaxseed, cumin, and star anise can be utilized to treat a variety of illnesses. Their medical efficacy is derived from chemicals that destroy microorganisms and boost human immunity, producing a specific physiological activity. Their pharmacological data can be used to create new and enhanced antimicrobial drugs.

In medicine, the usage of spices and their phytochemicals can be very important. The lack of scientific evidence regarding the antimicrobial activity of the medicinal plants mentioned above prompted us to assess the phytochemicals and antimicrobial activity found in the solvent extracts of these plants, which could offer scientific support for the conventional antimicrobials used to treat a variety of illnesses. [2]. Due to their antibacterial qualities, spices including flaxseed, cumin, and star anise can be utilized to treat a variety of illnesses. Their medical efficacy is derived from chemicals that destroy microorganisms and boost human immunity, producing a specific physiological activity. Their pharmacological data can be used to create new and enhanced antimicrobial drugs. In medicine, the usage of spices and their phytochemicals can be very important. The lack of scientific evidence regarding the antimicrobial activity of the medicinal plants mentioned above prompted us to assess the phytochemicals and antimicrobial activity found in the solvent extracts of these plants, which could offer scientific support for the conventional antimicrobials used to treat a variety of illnesses [3, 4]. These molecules known as phytochemicals or secondary metabolites give the spices their distinct flavor and scent. Spices contain a variety of phytochemical groups, such as flavonoids, anthocyanins, and isoflavonoids [5]. Herbs and spices are essential components of the human diet. For thousands of years, people have utilized them to improve the flavor, color, and scent of food. Herbs and spices are also well-known for their therapeutic and preservation properties. Their medical efficacy is derived from chemicals that destroy microorganisms and boost human immunity, producing a specific physiological activity. Their pharmacological data can be used to create new and enhanced antimicrobial drugs [6]. There are two primary reasons why food contains antimicrobials: 1. To regulate organic deterioration processes (food preservation). 2. To stop or manage the growth of microorganisms, including harmful ones (food safety). Natural antimicrobials come from microbial, plant, and animal sources. They have a lot of promise for use in food, particularly in fresh fruits and vegetables [7].

1.1. Spices used as antimicrobial agents

The antibacterial properties of essential oils Many common spices and herbs, including garlic, mustard, cinnamon, cumin, clove, bay, thyme, basil, oregano, pepper, ginger, sage, rosemary, and others, are being studied for their ability to combat the majority of food-contaminating bacteria and fungi, including *Salmonella, Pseudomonas, Aspergillus, Cladosporium*, and many others. The type of spice or herb, the food and microorganism, the chemical makeup and content of extracts and essential oils, and other factors all affect antimicrobial effectiveness [8]. Aqueous decoctions of black pepper (*Piper nigrum* L.), bay leaf (*Laurus nobilis* L.), aniseed (*Pimpinella anisum* L.), and coriander (*Coriandum sativum* L.) were found to have antibacterial properties against 176 bacterial isolates from 200 individuals' oral cavities, representing 12 different genera. The method of disc diffusion was used. At a concentration of 10µl/disc, the aqueous decoction of black pepper was the most bacterially toxic, exhibiting 75% antibacterial activity, in comparison to the aqueous decoction of bay leaf (53.4%) and aniseed (18.1%). When tested against bacterial isolates, the aqueous decoction of coriander exhibited little antibacterial activity [9]. Using the disk diffusion method as a preliminary screening, the antibacterial activity of 14 spices—including cardamom, cinnamon, clove, coriander, cumin, garlic, ginger, holy basil, kaffir lime leaves and peels, lemongrass, mace, nutmeg, black and white pepper, and turmeric as well as their crude ethanolic extracts and essential oils were tested against 20 *Salmonella* serotypes and five other enterobacteria species. Eleven essential oils and nine crude ethanolic extracts were chosen from among these in order to use the microbroth dilution test to find the minimum inhibitory concentrations (MICs). Clove extract was the most effective ethanolic extract at inhibiting the growth of all tested bacterial strains. Oils of clove and kaffir lime peels exhibited greater antibacterial activity against all tested strains, compared to other spice oils [10].

Extracts from *Allium sativum* (garlic), *Zingiber officinale* (ginger), and *Piper nigrum* (pepper) have been tested for their ability to inhibit the growth of bacteria, including *Proteus vulgaris, Morganella morgani, Escherichia coli, Morganella pneumoniae*, and *Klebsiella pneumoniae*. Garlic extract demonstrated outstanding antibacterial activity against *P. vulgaris* and *M. morgani*, and it demonstrated great antimicrobial activity against nearly all tested pathogens out of the 10 extracts that were examined for antimicrobial activity. However, the pepper extract exhibited the

least amount of antibacterial action against the test organisms, while the ginger extract only shown a modest level of activity against *P. aureus* [11].

2. Cumin (*Cuminum cyminum*)

The aromatic plant cumin (*Cuminum cyminum*) is a member of the Apiaceae family. In the Middle East, cumin has long been used as a culinary element, while in India, cumin seeds have long been used as a disinfectant and antiseptic. The main bioactive components of cumin EOs include terpenoids, cymene, and cuminaldehyde [1]. In South East Asia, Arabia, and India, cumin is a common spice condiment. Cumin, sometimes referred to as Kashmiri jeera or jeera, is a member of the Apiaceae family. The carminative, stimulant, diuretic, emmanogogic, antispasmodic, and astringent qualities of cumin are well-known. Numerous pathogens, including *Salmonella* species, *Bacillus cereus, Aspergillus niger, Staphylococcus aureus*, and *Escherichia coli*, have been shown to be inhibited in their growth by cumin aqueous extract [12]. Although N. sativa seed volatile oil possesses therapeutic and neuroprotective properties against sciatic nerve injury, these benefits have mostly been seen in terms of the quantity and shape of neurons. In general, cumin seed oil may be a dietary supplement that improves cognition, memory, and attention [13]. Its dried and crushed fruits are often steam-distilled to extract the 2-5% volatile oil found in the fruits. Traditional and veterinary remedies employ cumin as a stimulant, astringent, and carminative to treat indigestion, diarrhea, and flatulence. The primary chemical components of cumin are cuminaldehyde, cymene, and terpenoids, which together make up its EO content (2.5–4.5%), which is the most significant component of cumin and may have antibacterial and antioxidant properties.

2.1. Antimicrobial activity of *Cuminum cyminum*

The antibacterial effects of cumin (*Cuminum cyminum*) seed methanolic extract against four food-spoiler and enteropathogenic bacterial strains. Both gram-positive and gram-negative bacteria can be effectively combatted by the cumin extract. A rise in absorbance between 260 and 280 nm suggests that bacterial cultures treated with cumin extract have damaged cell membranes, which results in the release of internal nucleotides and proteinaceous components from the cells. Minimum amounts of cumin extract that are effective against *Bacillus pumilius, Pseudomonas aureus, Staphylococcus aureus,* and *Escherichia coli* [12]. Cumin essential oil's antibacterial properties against the bacterial flora of teeth that are unresponsive to root canal therapy. *Cuminum cyminum* essential oil was biocompatible with L929 mice fibroblasts and had potent antibacterial action against the microbial flora of teeth following unsuccessful endodontic treatments [14]. Cumin oil has strong to moderate antifungal activity against three fungal isolates (*Aspergillus flavus, Candida albicans*, and *Cryptococcus* sp.) and strong antibacterial activity against four clinical bacterial isolates (*Escherichia coli*, *Staphylococcus aureus*, *Klebsiella* sp., and *Pseudomonas aeruginosa*). The clinical isolates of bacteria were subjected to the minimum inhibitory concentration (MIC) of the cumin extracted oil; the most susceptible isolate, E. coli, had the lowest MIC value .*N. sativa* is rich in natural compounds that have the potential to be used therapeutically in vitro. These include organic antioxidants that have antibacterial and antifungal properties, as well as antidiabetic, anti-inflammatory, anti-cancer, and wound-healing effects. In countries like Iran and Pakistan, *N. sativa* has long been used traditionally to treat bacterial infections [15].

3.Star anise (*Illicium verum*).

A potent plant, star anise is used extensively in Asian and traditional Chinese medicine. The fruit has a slightly sweet and spicy flavor, and its aroma is present. It contains a number of flavonoid and polyphenolic chemicals that have anti-inflammatory, anti-fungal, anti-oxidant, and antibacterial properties [16]. A significant herb that grows widely in the southwestern regions of Asia is star anise (*Illicium verum*), a medium-sized, evergreen tree with fruit shaped like a star.Additional potentials of star anise include sedative, expectorant, spasmolytic, antibacterial, antifungal, anthelmintic, insecticidal, secretolytic, antinociceptive, anti-inflammatory, gastroprotective, and estrogenic actions [17].

The plant Illicium verum is abundant in lignans and sesquiterpenes of the seco-prezizaane type [18]. From a chemical perspective, these chemicals are thought to be distinctive chemical

identifiers of the Illicium species since they are unique structural types that only occur in the species [19]. According to reports, these components have a variety of biological actions, such as neurotrophic and neurotoxic effects [20]. Shikimic acid, a key component of Tamiflu (oseltamivir phosphate), an antiviral medication thought to be a treatment for the bird flu H5N1 virus, is produced industrially from star anise. The only medication now on the market that may lessen the severity of avian flu is oseltamivir. A recognized neurotoxic makes the closely related species Japanese star anise (*I. anisatum* L.) inedible. Star anise tea use may be the cause of recorded cases of disease, including severe neurologic and gastrointestinal toxicities such convulsions, diarrhea, and vomiting [21].Its toxicity has been demonstrated to be caused by the fruits' sesquiterpenes, including anisatin and neoanisatin [22]. In traditional medicine, Japanese star anise can be used to treat some skin conditions, but it is not recommended for internal usage [23].

3.1. Antimicrobial activity of Star Anise (*Illicium Verum)*

According to the agar diffusion method, the crude ethanolic extract from the fruit of Illicum verum Hook exhibited antibacterial activity against S. aureus ATCC 25923, *E. coli* ATCC 25922, *P. aeruginosa* ATCC 27853, *C. albicans, A. flavus,* and *T. mentagrophytes*. Three-part hexane, dichloro methane, and methanolic extracts were used in subsequent fruit extractions. When applied to *T. mentagrophytes*, crude hexane and crude dichloromethane extracts exhibited antifungal efficacy. The antibacterial activity of crude methanolic and crude dichloromethane extracts against S. aureus ATCC 25923 K was demonstrated [24].(Aqueous methanolic (50%) extract's antibacterial activity against methicillin-resistant Staphylococcus aureus (MRSA USA300) and multidrug resistant *Acinetobacter baumannii* AB5057 was examined in vitro using the disc diffusion assay, minimum bactericidal concentration determination, anti-biofilm activity, and biofilm detachment activity. A mouse model of MRSA skin infection was used to investigate the antibacterial activity in vivo. Significant inhibition and detaching activity against biofilm formation by the highly pathogenic and multidrug resistant *Acinetobacter baumannii* AB5057 and MRSA USA300 were demonstrated in vitro by the star anise aqueous methanolic extract. The extract's topical administration in vivo considerably decreased the bacterial load in skin lesions infected with MRSA. Using five distinct complementary methods, the extract demonstrated high antioxidant activity [25].

In comparison to *Artemisia vulgaris*, star anise has a greater and more potent antioxidant activity against DPPH, with a calculated value of 78.3% at 750 ppm, 65.3% at 500 ppm, and 23.3% at the lowest concentration of 250 ppm. Furthermore, both extracts demonstrated strong antifungal properties [26]. It has been discovered that Illcium verum essential oils are powerful antioxidants and antibacterials against both Gram-positive and gram-negative bacteria [27]. Illicium verum's leaves and twigs have a lot of potential for use as novel natural antibacterial agents [28].

4. Flaxseed (*Linum usitatissimum*)

Linseed (*Linum usitatissimum*), another name for flaxseed, belongs to the Linaceae family's genus Linum [29]. Flaxseed protein extraction did demonstrate antibacterial efficacy against a variety of gram-negative bacteria. In comparison to commonly used synthetic-based antimicrobial chemicals, flaxseed extract may include natural antibacterial properties that can be utilized to treat a variety of oral health issues with fewer negative effects. Flaxseed lignin extract may include antibacterial and antioxidant compounds.Lipids, proteins, lignans, fibers, and minerals are the primary components of flaxseed.Using successive solvent extraction, the albumin, globulin, and glutelin fractions were separated from the defatted flaxseed meal. Antioxidants including tocopherols, betacarotene, cysteine, and methionine, which are abundant in flaxseed, lower blood pressure, heart disease, neurological and hepatic conditions, and improve insulin sensitivity. Because of its antidiabetic and anticancer properties, as well as its positive effects on cardiovascular, gastrointestinal, hepatic, urological, and reproductive problems, flaxseed is widely utilized and considered a medicinal plant [30,31,[32]. Consumption of flaxseed (*Linum usitatissimum* L.) has surged because of its possible health advantages, which include defense against diabetes, cancer, cardiovascular disease, and inflammation. Flax protein supports the immune system and aids in the prevention and treatment of heart disease. Baked goods, juices, milk and dairy products, muffins, dry pasta products, macaroni, and meat products have all used flax or flaxseed oil as a functional food ingredient. The evidence

of flaxseed's possible health advantages from recent research on humans and animals as well as its commercial application in a variety of food products is the main topic of this review [33].

4.1. Antimicrobial activity of *Linum Usitatissimum*

The antibacterial activity of ethanolic extract of flax seeds against *Bacillus cereus*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Klebsiella pneumoniae.* Flax seeds extract mouth rinse reduced the number of colonies equally as that of commercially available mouth rinse. Flax seeds might be the effective source of antibacterial compounds and the promising alternative to antibiotic therapy [34]. *Linum usitatissimum* methanolic extract exhibited the best inhibitory activity on all tested strains compared to the other extracts [35]. Flaxseed extract can be used as a novel antimicrobial agent in fresh cut vegetables [36]. Extracts derived from Flaxseed might be the active source of antibacterial compounds and the hopeful alternate to antibiotic therapy [37].

Conclusion

It is concluded that composition of spices contains natural antimicrobial products. Products made from spices could be used to treat infectious infections instead of standard antibiotics.of spices on people ought to be assessed. The antimicrobial potential reveals that scientific validation of natural spices products for the use as an antimicrobial agents. It may be concluded that *Cuminum cyminum, Illicium verum* and *Linum usitatissimum* can be used as a potential source of natural antimicrobial agents in place of commercially available synthetic agented drugs that may have side effects.

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