



Research Article

ANTIMICROBIAL PROPERTIES OF SEED SPICES AND THEIR EFFECT ON PATHOGENIC MICROORGANISMS

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Abstract: Currently, several thousands of diseases are attacking human population, and to tackle them it has become substantial for us to explore the antibiotics. Synthetic antibiotics available in market have its own side effects. Recently, the use of natural products has become ideal for treatment of microbial infections. Hence, scientists are in pursuit of antibiotics which are naturally present in plants. As a result, most of the world's population uses spice materials as traditional medicine because of their strong antimicrobial properties. The application of spices in treating ailments would be an ideal alternative and can also open up opportunities for the development of anticancer, antimicrobial, and antiviral drugs with lower side effects. Several research works have been carried out in spices that suggest their usage as a potential antimicrobial agent. Pharmacological properties of seed spices viz., Cumin, Coriander, Fennel, Fenugreek, Ajwain, Dill, Black cumin, Celery, Aniseed and Caraway with good potential for antimicrobial, antiviral, and radical scavenger abilities is observed. Taking into consideration the significant role of antimicrobial drugs on human, plant and animal life that are free from side effects will help to cure widespread diseases of day-to-day life of population.

Keywords: Anti- microbial, Spices, Synthetic drugs, Essential oils, Bioactive compounds

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Introduction

The term seed spice refers to dried seeds or fruits of annual herb that are used as spices. It is an important group of agricultural commodities and play a significant role in the nation's economy. The states, Rajasthan and Gujarat together contribute more than 80 per cent of the total seed spice production of the country [1]. Seed spices produce numerous secondary metabolites or phytochemicals, these are naturally occurring and comprise biologically active chemical compounds, which act as a natural defense system for host plants. Secondary metabolites have been historically used in pharmaceuticals, fragrances, flavor compounds, dyes, and agrochemical [2]. Antimicrobials are also classified as synthetic and herbal antimicrobial agents according to their different chemical substances. Antimicrobial agent or antimicrobial drug defined as an agent which is used to kill microorganisms or stop their growth. It can be categorized based on the kind of primary microorganisms they act against, such as bacteria and viruses. For instance, if it acts against bacteria, they are called antibiotics.

Synthetic antimicrobial agents are used to control microbial infections. But synthetic antimicrobial agents create numerous side effects and in order to counteract these issues the search for "naturally derived" sources is the need of the hour [3]. Plants are known to produce different secondary metabolites that show antagonistic reactions against pathogens [4]. Hence plant-derived spices and their essential oils that contain different bioactive compounds can be utilized for the production of naturally derived antimicrobial drugs. These components are generally recognized as safe (GRAS) with no side effects. The bioactive constituents of spices can be divided into volatile and non-volatile compounds and the volatile compounds present in spices are mainly responsible for the antimicrobial activity. In this regard seed spices could be exploited as a good alternative.

Antimicrobial properties of seed spices and their defense mechanism

Phytochemicals present in seed spices are Alkaloids, Flavonoids, Phenolic compounds, Terpene, Essential oil and Saponin

Alkaloids

It is the largest group of secondary chemical constituents among the phytochemicals present in the plants [10]. It acts against microorganisms as it possess the ability to intercalate with DNA, thereby disrupting transcription, replication & also inhibits cell division, resulting in cell death. Alkaloids present in seed spice fenugreek are trigonelline (0.2-0.36%), choline (0.5%), gentianine and carpine.

Tannins

This group of phytochemicals is widely distributed in plant flora. Mostly found in root, bark, stem and outer layers of plant tissues. Its mode of action against the microorganism is by inactivation of cell envelope transport proteins such as adhesins, enzyme inhibition, or disruption of cell membranes [11]. The tannin compound is present in the seed spice coriander and fennel.

Essential oil

Essential oils are odorous volatile liquids found in flowers, roots, barks, leaves, seeds, fruits, and wood. Active compounds present in essential oil containing hydroxyl group (-OH) are highly responsible for their antimicrobial activity. The hydroxyl groups can be easily bind to the active site of enzymes and alter their metabolism. Coriander and ajwain the essential oil contain linalool and thymol respectively [12].

Antimicrobial Properties of Seed Spices and Their Effect on Pathogenic Microorganisms

Table-1 Bioactive compounds of seed spices and their uses [Peter, (2002)]

Name	Scientific name and family	Parts used	Major compound	Uses
Coriander	<i>Coriandrum sativum</i> Apiaceae	Leaves & Seeds	Linalool	Carminative, diuretic, digestive, stimulant, anti-inflammatory, antioxidant
Fenugreek	<i>Trigonella foenum-graecum</i> Fabaceae	Leaves & seeds	Diosgenin, trigonelline and 4-hydroxyisoleucine	Carminative, tonic, aphrodisiac, antibacterial, diabetes and oral contraceptive
Cumin	<i>Cuminum cyminum</i> Apiaceae	Seeds	Cuminaldehyde, β -pinene and γ -terpinene	Gastrointestinal, antimicrobial, antioxidant
Fennel	<i>Foeniculum vulgare</i> Apiaceae	Seeds	Anethole fenchone & phenols	Antioxidant, anticancer, stimulant, carminative, stomachic, aphrodisiac and antimicrobial
Ajwain	<i>Trachyspermum</i> Apiaceae	Seeds	Thymol, γ -terpinene, p-cymene, palmitic acid and xylene	Digestive, mild stimulant, stomachic, carminative, aphrodisiac, antiseptic, antifungal, antibacterial
Black cumin	<i>Nigella sativa</i> Ranunculaceae	Seeds	Nigellone & thymoquinone, thymohydroquinone	Diuretic, antihypertensive, antidiabetic, anticancer, analgesic, antimicrobial, anthelmintics & antioxidant properties antiviral
Celery	<i>Apium graveolens</i> Apiaceae	Leaves and Seeds	d-limonene (60%), β -selinene (10-12 %)	Antioxidants, digestion
Caraway	<i>Carum carvi</i> Apiaceae	Seeds	Carvone (60%) and limonene	Antispasmodic, antiseptic, antiparasitic, lactogenic, aromatic, carminative, digestive, and stimulant

Table-2 Antiviral properties of black cumin

Crop	Bio active compound	Virus	References
Black cumin	Nigellone Thymoquinone Thymohydroquinone	Avian influenza (H9N2)	[5]
		Antiviral	[6]
		Hepatitis C virus	[7]
		HIV protease enzyme	[8]
		SARS-CoV-2	[9]

Table-3 Antimicrobial effect of Seed Spices on Human Pathogenic Organisms

Spices	Extraction	Bioactive Component	Microorganism	References
Black cumin	Essential oil	36-38% fixed oils, proteins, alkaloids, saponin and 0.4 -2.5% essential oil	<i>Aeromonas hydrophila</i> (Endocarditis)	[18]
Fenugreek	Aqueous Extract	Seed saponin	<i>S.aureus</i> (abscesses), and <i>E. coli</i> (diarrhea)	[19]
Caraway	Essential oil	Carvone (60%) and limonene	<i>S.aureus</i> (abscesses), and <i>E. coli</i> (diarrhea)	[20]
Coriander	Aqueous decoctions and infusion	Flavonoids -quercetin, kaempferol, rhamnetin, and Phenolic acid	Gram-positive and Gram-negative bacteria, including <i>Listeria monocytogenes</i>	[21]
Celery	Essential oil	Limonene	<i>Bacillus subtilis</i> (septicemia)	[22]
Aniseed	Essential oil	Anethole	<i>Saccharomyces cerevisiae</i> (pneumonia) <i>Candida albicans</i> (Digestive issues)	[23]
Fennel	Essential oil	Trans-anethol, fenchone, estragole	<i>E. coli</i> (diarrhea) and <i>B.subtilis</i> , (septicemia)	[24]
Ajwain	Essential oil	Carvacol and thymol	<i>Klebsiella pneumoniae</i> , <i>E. coli</i> , <i>Staphylococcus aureus</i> (abscesses)	[25]
Cumin	Essential oil and alcoholic extract	Cuminaldehyde	<i>Aspergillus niger</i> (acute hepatitis) & <i>E. coli</i> (diarrhea)	[26]
Dill	Essential oil	Limonene, carvone, anetho furan	<i>Aspergillus flavus</i> (acute hepatitis)	[27]

Table-4 Antimicrobial effect of Seed Spices on Plant Pathogenic Organisms

Spices	Bio active compound	Disease	Crop	Causal organism	References
Cumin	Cuminaldehyde	Bacterial leaf spot	Tomato	<i>X. campestris</i> pv. <i>vesicatoria</i> , <i>X. campestris</i> pv. <i>campestris</i>	[28]
Fennel	Anethole	Wilt of tomato	Tomato	<i>Fusarium oxysporum</i> f. sp. <i>Lycopersici</i>	[29]
Aniseed	Trans - anethole	Rot	Apple	<i>Botrytis cinerea</i>	[30]
Caraway	Carvone (60%) and limonene	Root rot	Peas	<i>Sclerotium rolfsii</i>	[31]
Ajwain	Thymol	Curvularia leaf spot and wilt	Cassava and guava	<i>Curvularialunata</i> , <i>Fusarium chlamydosporum</i>	[32]
Coriander	Linalool	Rice seedling blight, Leaf spot	Rice and Chilli	<i>Pyriculariaoryzae</i> & <i>Alternaria</i> sp	[33]
Dill	Carvone	Sclerotinia Rot	Rapeseed	<i>Sclerotinia sclerotiorum</i>	[34]

Table-5 Antimicrobial effect of Seed Spices on Animal Pathogenic Organisms

Spices	Bio active compound	Animal	Microorganism	References
Coriander	Linalool	Cat & Dog	<i>Microsporium canis</i> (upper, dead layers of skin)	[35]
Dill	Carvone	Dog	<i>Candida albicans</i> (abnormal amount of drooling)	[36]
Fennel & Ajwain	Anethole, thymol	Cat & Dog	<i>Microsporium gypseum</i> , (ring worm) <i>Microsporium canis</i> (circular lesions)	[37]
Caraway	Carvone (60%) and limonene	Poultry and pig	<i>Clostridium perfringens</i> (enterotoxemia)	[38]
Black Cumin	thymoquinone	Bovine	<i>Coagulase</i> - negative <i>Staphylococci</i> (mastitis)	[39]

Flavonoids

It is an important group of polyphenols, synthesized in the cytoplasm of the plant cell and then accumulate in vacuoles that fuse with the central vacuole of epidermis and cortex cells [13]. Till date more than 4000 distinct flavonoids are identified, among them nearly 70% of the flavonoids are present in plants. Flavonoids interact with membrane proteins that are present in bacterial cell walls increasing the permeability of the membrane and disrupting it and then cause cell

death [14]. The flavanoid compound present in the seed spice fennel is quercetin.

Phenolics

The color of fruits and flowers is due to the presence of polyphenols. These are a series of pigment compounds with the quinonic structure. Phenolic compounds sensitize the phospholipid bilayer of the microbial cytoplasmic membrane causing increased permeability and unavailability of vital intracellular constituents[15].

Table-6 Extraction methods of active principles of seed spices

Crop	Form	Extraction method	Bio active compound	Compound analysis	References
Coriander	Essential oil	Steam distillation	Linallol	Gc-MS analysis	[40]
Fenugreek	Crude extract	Microwave Assisted Extraction	Diosgenin		[41]
Fennel	Essential oil	Hydro distillation	Trans anethole		[42]
Cumin	Essential oil	MW-assisted hydro distillation	Cuminaldehyde		[43]
Black cumin	Essential oil	Subcritical CO ₂ extraction	Thymo Quinine		[44]
Dill	Essential oil	Supercritical carbon dioxide	D-carvone, D-limonene		[45]
Ajwain	Essential oil	Hydro distillation	Thymol		[46]
Celery	Essential oil	Ultrasound-Assisted Hydro distillation	Limonene		[47]
Caraway	Essential oil	supercritical fluid extraction	Carvone		[48]
Aniseed	Essential oil	Hydro distillation	trans-Anethole		[49]

Saponins

Saponins are compounds derived from steroids or triterpenoid glycosides, which occur in many plants and act on microbial cells by permeabilization of the membrane [16]. Diosgenin is a saponin present in the seed spice of fenugreek (2 to 7%). Among the numerous advantages of natural antimicrobial agents, it is often stated that bacteria do not develop resistance to herbal medicines, or at least the low level of resistance since they possess high antimicrobial potential at lower prices [17]. Such naturally obtained antimicrobial agents are less toxic and free of side effects compared to synthetic antimicrobial agents.

Conclusion

Seed spices are used in our day-to-day life. Other than culinary purpose, it has pharmaceutical significance as it possesses anti-oxidant & anti-microbial properties. Major seed spices like coriander, fenugreek, fennel, cumin have antimicrobial properties against human, plant, and veterinary pathogens. Not only major spices the minor seed spices like ajwain, celery, aniseed, caraway and dill also contain antimicrobial properties. Black cumin is one of the minor seed spices that contains anti-viral property which can be used in the preparation of medicines for the treatment of viral diseases like COVID-19. Due to all the beneficial properties present, the seed spices can be used in suitable pharmaceutical dosage to treat infections of human, plant & veterinary diseases.

Application of research: Plant-derived spices and their essential oils that contain different bioactive compounds can be utilized for the production of naturally derived antimicrobial drugs for controlling pathogenic organisms in the field of agriculture, veterinary and medicine.

Research Category: Seed Spices

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