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Health Benefits of Spices with Special Reference to Antimicrobial Activity and Bio Active Components

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ABSTRACT: A spice is a dried seed, fruit, root, bark or vegetative material used in nutritionally insignificant amount as a food supplement for the reason of flavouring and imparting taste. Spices are defined as "a strongly flavoured or aromatic substance of vegetable origin, obtained from tropical plants, commonly used as a condiment". In ancient times, spices were as valuable as metal gold; and as noteworthy as medicines and perfumes. No country in the world cultivates as a lot of kinds of spices as India with quality spices come from Kerala, an Indian state. Because of the varying climates in India-from tropical to sub-tropical, temperate-almost all spices are grown in this country. In almost all of the 28 states and seven union territories of India, at least one spice is grown in profusion. The present study was made on the antimicrobial aspects of spice with reference to bioactive components.

Key words: Spices, Antimicrobial activity, Pathogen, Food spoilage, Bio active components, Microorganism, Extract

Introduction

"An apple a day keeps the doctor away." Traditional American rhyme, but it can be replaced with "food cooked with Indian spices can keep doctors and physicians permanently away".

Food-borne diseases are still a major problem in the World, even in well-developed countries (Mead, P.S et al., 1999). A variety of microorganisms also lead food spoilage which is one of the most important concerns of the food industry. So far, many pathogenic microorganisms, such as *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Listeria monocytogenes* and *Campylobacter jejuni* have been reported as the causal agents of food borne diseases and/or food spoilage (Betts G.D, 1999; Deak T, 1996). Thus, at present, to prevent food spoilage, chemical preservatives are used to prevent the growth of food spoiling microbes in the food industry (Sagdic O, 2003). Due to consumer concerns about the safety of food containing synthetic chemicals as preservatives, there is a growing interest in the use of natural antibacterial compounds, like extracts of herbs and spices, for the preservation of foods, as these possess characteristic flavours and sometimes show antioxidant activity as well as antimicrobial activity (Smid E.J, 1999). For centuries, indigenous plants have been used in herbal medicine for curing various diseases (Cowan, 1999). Recently, the acceptance of traditional medicine as an alternative form for health care and the development of microbial resistance to the available antibiotics have led authors to investigate the antimicrobial activity of medicinal plants (Kumarasamy, 2002; Srinivasan, D et al., 2001).

History of spices

The early civilizations of the Mediterranean craved the spices of India and the lands eastward. The Egyptians used herbs and spices in their day activities. The Egyptian spice expeditions to east coast of Africa are recorded as early as three and four thousand years ago. Cinnamon and cassia were treasured spices. Medical documents show that Egyptian used anise, caraway, cassia, cardamom, mustard, sesame, fenugreek, saffron and other spices around 1550 BC. The spices were not only used to flavour foods but for body ointments, anointing oils and ceremonial functions including important burial rites. Spices are frequently mentioned in the Bible as a valuable commodity. The three wise men brought spices as one of the gifts for the baby Jesus.

The Roman started sailing to India from Egypt in the first century AD. Stars were the only navigation system available to these early spice traders. A round trip to India took as long as five years. Romans brought back fabulous cargos and rapidly became extravagant users of spices for perfumes, cosmetics, medicine and cooking.

In the present review, an attempt has been made to collect current physiological, antimicrobial and nutraceutical perspectives of chemicals from spices that we ingest regularly without much knowledge about them. In the process we shall highlight scientific evidence, extraction method and bioactive components behind the antimicrobial property of the spices. We anticipate that this shall provide a basis for a full scale investigation of the therapeutic potential of these staple dietary additives.

Turmeric

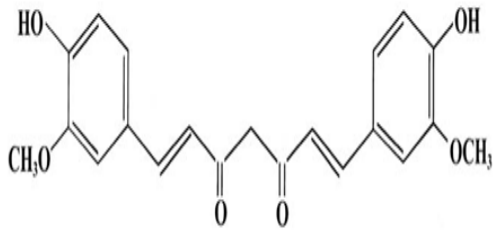
Curcuma longa, commonly known as 'turmeric', is widely used as a spice and colouring agent, and is known for its medicinal properties. Various sesquiterpenes (Oshiro et al., 1990) and curcuminoids have been isolated from the rhizome of *C. longa*, attributing a wide array of biological activities such as antioxidant, (Shalini J et al., 1992) anti-inflammatory, (Ghatak A et al., 1991) wound healing, (Chang H et al., 1987) anticancer and antiproliferative, antifungal and anti-bacterial activity.

The turmeric oil obtained by steam distillation is found to be active against *Staphylococcus epidermidis, S.aureus, Escherichia coli, and Salmonella thyphimurium,* while the chloroform, methanol and water fraction were inactive to the test organism (Ranbir Singh et al., 2002).

Turmeric oil is also active against *Aspergillus flavus*, *A. parasiticus*, *Fusarium moniliforme* and *Penicillium digitatum* (Jayaprakasha, G. K, 2001).

The ethanol extract of the rhizomes has anti-*Entamoeba histolytica* activity. Curcumin has anti-Leishmania activity in vitro (Koide, T et al., 2002). Anti-*Plasmodium falciparum* and anti-*L. major* effects of curcumin have also been reported (Rasmussen, H. B et al., 2000).

Fig 1. Chemical structure of curcumin [1, 7-*bis*-(4-hydroxy-3-methoxyphenyl)-1, 6-heptadiene-3, 5-dione]



Pepper

Black pepper (*Piper nigrum* L., Piperaceae) is used to treat asthma, chronic indigestion, colon toxins, obesity, sinus, congestion, fever (Ravindran, 2000) intermittent fever, cold extremities, colic, gastric ailments and diarrhoea (Ao et al., 1998). Black pepper is native to India and has been a prized spice since ancient times. It has been shown to have antimicrobial activity (Dorman & Deans, 2000). Both aqueous and ethanolic extracts of black pepper have been screened

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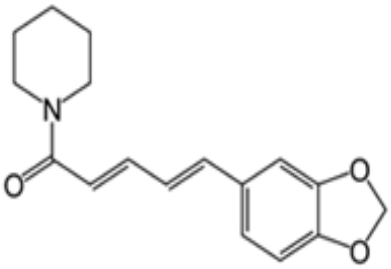
for antibacterial activity against a penicillin G resistant strain of *S. aureus* (Perez and Anesini, 1994), *Bacillus cereus* and *B. subtilis* (Singh et al., 2005). *Aeromonas hydrophila* , *Alcaligenes* sp, *Citrobacter* sp, *Enterobacter aerogenes*, *E. coli*, *Flavobacterium* sp., *Klebsiella ozaenae*, *K. pneumoniae* , *Micrococcus roseus*, *Plesiomonas shigelloides, Pseudomonas aeruginosa, Staphylococcus aureus, Streptococcus* anginosus*, Streptococcus morbillorium, Streptococcus mutans Streptococcus oralis* were found to show zone of inhibition to the aqueous extract of black pepper (Nazia Masood Ahmed Chaudhry and Perween Tariq, 2006). 250 ppm of piperine showed good antibacterial property against gram positive and gram negative bacteria (Pavithra Vani Karsha and O Bhagya Lakhsmi, 2009).

Fig 2: Chemical Structure of piperine
IUPAC name 1-[5-(1, 3-benzodioxol- 5-yl)-1-oxo-2, 4-pentadienyl] piperidine



Basil

Ocimum basilicum is in use for many years in the Indian Ayurvedic and Unani medicine for cough treatment, inflammations, dyspepsia, aches and pains. It is the queen of herbs and in India it is the holist herb. It is also used in food as a food spice (McClatchey, 1996) mentioned leaves of *O. basilicum* suitable for treatment of pain and cough. Basil, the essential oil from O. basilicum L., is shown to have an inhibitory effect on *Aspergillus ochraceus* (Basilico and Basilico, 1999) and antimicrobial activity (Hili et al., 1997**).**

The essential oil obtained by steam distillation from air dried basil leaves showed antibacterial activity against resistant clinical isolates from the genera *Staphylococcus, Enterococcus* and *Pseudomonas.* The minimum inhibitory concentrations (MICs) were reported between 0.0030% and 0.0007% (v/v). After gas chromatographic separation, the following components identified were linalol (54.95%), methylchavikol (11.98%), methylcinnamat (7.24%) and linolen (0.14%). (G. Opalchenova et al., 2002)

The crude aqueous extract was active against *Neisseria gonorrhea* (Shokeen P et al., 2005)

The ethanol extract of *Ocimum sanctum* was found to be active against *Staphylococcus aureus, Bacillus subtilis, Bacillus cereus, Bacillus thuringiensis, Salmonella typhi* at a minimum bactericidal concentration of 5 to 10 mg /mL (Bishnu Joshi et al., 2009).

Black Cumin

Nigella sativa L. (family Ranunculaceae) is commonly known as black cumin or black seed. The seed or its oil is used as a carminative, diuretic, lactagogue and vermifuge (Akgul, 1989; Ali and Blunden, 2003). The dried seeds from black cumin are also used for sprinkling on bread or flavouring foods, especially bakery products and cheese (Ustum et al., 1990; Takruri and Daneh, 1998). *Nigella sativa* seeds contain 36-38% fixed oils, proteins, alkaloids, saponin and 0.4 - 2.5% essential oil (Ali and Blunden, 2003).

The oil obtained from the seeds by extracting with hexane were screened for antibacterial activity at a concentration of 0.5%, 1.0% and 2.0% using agar diffusion method against twenty four pathogenic, spoilage and Lactic acid bacteria. The most sensitive bacterium against all of the oil concentrations was *Aeromonas hydrophila*, while the most resistant was *Yersinia enterocolitica*. Generally, lactic acid bacteria had more resistance than pathogenic and spoilage bacteria against black cumin oils (Muhammet Arici, 2005).

Coriander

Coriander (*Coriandrum sativum L.*, *Umbelliferae*) is considered both an herb and a spice since both its leaves and seeds are used as a seasoning condiment. The name coriander is derived from the Greek word koris which means bug and commonly famous as Cilantro. It is native to the Mediterranean and Middle Eastern regions and has been known in Asian countries for thousands of years. Coriander seeds have a health-supporting reputation that is high on the list of the healing spices. It has traditionally been referred to as an anti-diabetic (Gray and Flatt, 1999), anti-inflammatory and recently been studied for its cholesterol-lowering effects (Chithra and Leelamma, 1999). In addition, it is also used as carminative, diuretic, tonic, stimulant, stomachic, refrigerant, aphrodisiac and analgesic. The coriander seeds contain 0.5-1% essential oil and are rich in beneficial phytonutrients including carvone, geraniol, limonene, borneol, camphor, elemol, and linalool. Coriander's flavonoids include quercitin, kaempferol, rhamnetin and epigenin. Coriander also contains active phenolic acid compounds including caffeic and chlorogenic acid.

According to study made by N. M. A Chaudhry and P Tariq, 2006; S Saheed and P Tariq, 2007 the aqueous decoctions and infusion showed no antibacterial activity against Gram positive and gram negative bacteria. But the compounds aliphatic 2E-alkenals and alkanals, isolated from the fresh leaves of *C. sativum* were found to possess bactericidal activity against *Salmonella choleraesuis* (Isao et al., 2004).

Cardamom

Elettaria cardamomum as plant of Zingiberaceae family has its seeds used commonly. As a cooking spice, the darker seeds are removed from the seed pod and ground into a powder. Cardamom is primarily cultivated in southern India, Sri Lanka, Tanzania, and Guatemala.

Historically known as the "Queen of all Spices', cardamom has been used in India since ancient times. As a spice, cardamom is used in cuisine for curry, coffee, cakes, bread, and flavouring sweet dishes and drinks. The seed and the essential oil are used as a flavouring component in a variety of foods including alcoholic and non-alcoholic beverages, frozen desserts, candies, baked goods, puddings, condiments, relishes, gravies, meat, and meat products.

Another use of Cardamom is in traditional Chinese and Indian medicine as a digestive aid, and for the treatment of intestinal gas.

Seeds from *E. cardamomum* have antibacterial gram-negative bacterium (Mahady et al., 2005), the content of essential oil in the seeds is strongly dependent on storage conditions, but may be as high as 8%. α-terpinyl acetate is present in cardamom around (20-53%).

The diethyl extract of the cardamom spice showed antimicrobial activity against *M. smegmatis, K. pneumoniae, S. aureus, E. coli, S. typhimurium, E. faecalis, M. luteus and C. albicans* (Sema Agaoglu, 2005).

Fenugreek

Fenugreek, also known by its formal name *Trigonella foenum-graecum*, is an herb native to India and used traditionally in the Ayurvedic medical system. A 2004 Asia Pacific Journal of Clinical Nutrition article says these seeds are also used as a food and offer a supreme nutritional profile. It is high in the amino acids lysine and tryptophan, fiber and rare constituents that give it its extensive effects as a health-promoting herb.

Aqueous extract of all fenugreek plant parts (roots, leaves, stems, ground seeds and non ground stem) showed antifungal potential and the magnitude of their inhibitory effects was species and plant parts dependent. Root extract was shown less toxic (30.38%), whereas Non Ground Seed extract expressed the strongest inhibition. Screening indicated that *Pythium. aphanidermatum* was the most resistant species, with an average inhibition of 34.5%. *Fusarium graminearum*, *Alternaria* sp. and *Rhizoctinia solani* were the most sensitive species and were similarly inhibited (63.5%) (R. Haouala et al., 2008).

Bay leaf

Bay leaf (*Laurus nobilis L., Lauraceae*) is culinary plant and has a long tradition of use in the Chinese and Ayurvedic systems of medicine. Bay leaf is traditionally used as an analgesic to treat a variety of complaints, neuralgia and intestinal cramps and still

occasionally being valued for its beneficial effect upon the digestive system. Bay leaf oil tested for its bactericidal activity has shown to be active against *Salmonella enterica* and *E. coli* (Friedman., et al 2002). Ethanol, water and n-Hexane extracts of bay leaves have been evaluated for cytotoxic properties using the brine shrimp bioassay. This study indicates that only the n-hexane extract exhibits cytotoxic activity (Kivcak and Mert, 2002). Aqueous decoction of bay leaf were sensitive to *Streptococcus intermedius, Salmonella typhi, Pseudomonas aeruginosa, Micrococcus roseus, Escherichia coli ,Flavobacterium sp. Klebsiella ozaenae , Klebsiella pneumonia, Aeromonas hydrophila*.(Nazia Masood Ahmed Chaudhry and Perwain Tariq, 2006).

The essential oil, also called laurel leaf oil, various volatile components with antimicrobial activities against bacteria, yeasts, and some molds were identified (Fiorini, C et al., 1997; Caredda A et al., 2002; Akgul et al., 1989). 1, 8-Cineole was the major component in all cases (Diaaz-Maroto, 2002).The presence of linalool, R-terpinyl acetate, and several monoterpene hydrocarbons such as α-pinene and sabinene was also determined.

Fennel

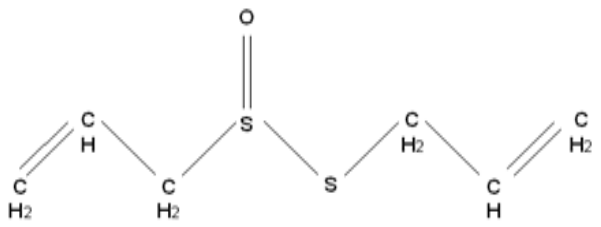
Fennel (*Foeniculum vulgare* Miller), a plant belonging to the family Apiaceae, has a long history of herbal uses. Traditionally, fennel seeds are used as anti-inflammatory, analgesic, carminative, diuretic and antispasmodic agents (M Oktay et al., 2003). Recently there has been considerable interest in the antioxidant potential and antimicrobial activities of fennel seed extracts and essential oil. The fennel essential oil and extracts were individually tested against a panel of microorganisms, including two bacteria, *Escherichia coli* B10 *and Bacillus subtilis* SPS2*,* and three pathogenic fungi *Aspergillus niger* ATCC 10 575*, Fusarium solani* ATCC 36 031 and *Rhizopus solani.* The essential oil showed considerable antimicrobial activity against the test organisms whereas the methanol and ethanol extracts were found to posses no antimicrobial activity (Farooq Anwar et al., 2009)

Garlic

Garlic (*Allium sativum* L.) exhibit a broad antibiotic activity against both gram positive and gram negative bacteria (Whitemore B B, 2000).The raw juice of garlic was effective against many common pathogenic bacteria (Kumar A and Sharma V.D, 1982), against the strains that have become resistant to antibiotics (Jezowa L et al., 1966) and even toxin production by some pathogenic strains prevented by garlic (Dewitt J.C.et al., 1979). There are extensive reports on the antibacterial activity of garlic juice, aqueous and alcoholic extracts, lyophilized powders, steam distilled oil and other commercial preparations of garlic. Han et al., 1995 reported that the antibiotic activity of 1mg of allicin, is equated to that of 15 IU of penicillin. The aqueous garlic extract at 25 % was sensitive to *Aeromonas caviae ,A. hydrophila ,A. sobria, Chromobacterium violaceum, E. coli ,Enterobacter faecalis, Klebsiella pneumonia, Proteus mirabilis, Pseudomonas aeruginosa, Salmonella mgulani, S. typhi ,S. roan ,S. senflenberg, S. thyphimurium, S. weltevreden , Bacillus subtilis and S.aureus* (Srinivasan Durairaj, Sangeetha Srinivasan and P. Lakshmanaperumalsamy, 2009).

M. Yusha'u et al., 2008 in his study mentioned that the ethanol extract of garlic on the other hand is also active against the test organisms with highest activity on *E. coli* (51mm) at 200µg/disc. It is also very active on *Pseudomonas* with the least activity seen against *Proteus vulgaris.*

Fig 3: The chemical structure of Allicin



Ginger

Zingiber officinale (Ginger), belonging to the family, Zingiberaceae is widely used around the world as a spice or food additive and medicine. This plant is a perennial herb consisting of an underground stem or rhizome, bearing erect leafy shoots. The pungent element of ginger is due to oleoresin-gingeroles, shogaols and zingerone. Ginger has been described in the treatment of catarrh, rheumatism, nervous diseases, gingivitis, toothache, asthma, stroke, constipation and diabetes.

According to Onyeagba R.A et al., 2004 the crude extracts of ginger applied singly and in combination with garlic did not exhibit any in vitro inhibition on the growth of test organisms but the ethanolic crude extract showed inhibition against *S.aureus* and *Bacillus* sp.

M. Yusha'u et al., 2008 reported that the ethanol extracts of ginger showed remarkable activity against all the test organisms with the highest activity on *E. coli* (35 mm zone diameter) at 200µg/disc concentration.

Mustard

Mélanie Turgis et al., (2009) reported that the essential oil of mustard reduces the intracellular ATP concentration and pH, and increases the extracellular ATP concentration in *Escherichia coli* and *Salmonella typhi*. They demonstrated that mustard essential oil affected the cell membrane integrity, resulting in a loss of cell homeostasis.

Allyl isothiocyanate is the bioactive component beside antibacterial activity (Shelef, L. A. 1983).

Mustard has been found to have strong inhibitory effect and it is also active against mycotoxic *Aspergillus* (Azzouz, M. A. and Bullerman, L. R., 1982).

An aqueous extract from the seeds of *Brassica negra* (black mustard) was shown to be effective in reducing the numbers of viable planktonic and sessile cells of a *Pseudomonas* sp., the fungus *Aspergillus fumigatus* and a mixed sulphate-reducing bacteria (SRB) culture (Sandra G. Gomes de Saravia and Christine C. Gaylarde, 1998)

Biosynthesis

Allyl isothiocyanate comes from the seeds of black mustard or brown Indian mustard (*Brassica juncea*). When these mustard seeds are broken, the enzyme myrosinase is released and acts on a glucosinolate known as sinigrin to give allyl isothiocyanate (Chemical formula $CH_2{=}CHCH_2NCS$).

Allyl isothiocyanate serves the plant as a defense against herbivores; since it is harmful to the plant itself, it is stored in the harmless form of the glucosinolate, separate from the myrosinase enzyme. When an animal chews the plant, the allyl isothiocyanate is released, repelling the animal.

Tamarind

The fruit pulp is used in syrup, juice .The presence of alkaloids, flavonoids, tannins and saponin may be responsible for the antimicrobial activity in the dry fruit pulp of *T. indica* and indicates that the species is medically important. It is used in the form of concentrates and exotic food-specialties like chutney, curries, pickles and meat sauces.

In crude ethanolic extract there was a strong activity against *E. coli* followed by *K. pneumoniae* and *S. paratyphi* A , whereas the water soluble extract showed strong activity against *P. aeruginosa* but moderate against *E. coli* and *K. pneumoniae*. It showed activity against *E. coli*, *P. aeruginosa*, *K. pneumoniae* and *S. paratyphi A*. (S. Y. Daniyan and H. B. Muhammad, 2008)

The tamarind pulp extracts exhibited remarkable anti-microbial activities against the tested micro-organisms in the order of sensitivity as *Salmonella typhimurium* (NCIM 2501)>*Staphylococcus aureus* (NCIM 5021)>*Bacillus cereus* (NCIM 2156)>*Pseudomonas aeruginosa* (NCIM 2036)>*Micrococcus luteus* (NCIM 2103)>*Escherichia coli* (NCIM 2089)>*Proteus vulgaris* (NCIM 2027)>*Aspergillus niger* (NCIM 545) (Dipali.Y.Jadhav et al.., 2010).

Cinnamon

Cinnamon (*Cinnamomum cassia*) of the family Lauracease is also known as Sweet wood. It contains medicinally important essential oil in leaves, fruits inner and outer bark. Much of cinnamon's bioactivity resides in its oil, which is about 90% cinnamaldehyde. It is used mainly in medicine, foods and cosmetics (Bown, 1995), and

is employed in aromatherapy as a rub to promote blood circulation. It also contains both anti-fungal and anti-bacterial principles that can be used to prevent food spoilage due to bacterial contamination (Fabio et al., 2003).

According to the study made by N. M. A Chaudry and Perwain Tariq (2006) the antimicrobial properties of cinnamon is more in essential oils than aqueous decoction and infusion because cinnameldehdye is volatile component. The oil was found highly effective against *Streptococcus oralis, S. anginosus*, *S. intermedius* and *S. sanguis*, *Enterobacter aerogenes* and *Micrococcus roseus*.

Based on the report of D. Ayfer Ates et al ., (2003) the alcoholic extract of cinnamon showed antibacterial activity against *B. megaterium* and *E. faecalis,* but the ethyl acetate and chloroform extract did not show any inhibition.

Star anise

Illicium verum is commonly known as star anise and it is non poisonous. It is mostly used in culinary preparation and in medicines. It is distributed in North America, Atlantic and the tropical and subtropical zones of Asia. Anithole is the bioactive component.

The ethanol extracts of *I. verum* fruits showed MIC at 16 mg/mL concentration for *Aspergillus niger*, *Candida albicans*, *Microsporom canis* and 4 mg/mL for *Epidermaphyton fluccosum* and *Trichophyton mentagrophytes*. The Minimum Fungicidal Concentration (MFC) recorded for *I.verum* was different from 8 to 256 mg/mL (Yazdani D et al., 2009)

Conclusion

Spices constitute an important group of agricultural commodities which are virtually valuable in the culinary art. In India, spices are important commercial crops from the point of view of both domestic consumption and export. Besides, huge quantities of spices are also being consumed within the country for flavouring foods and are also used in medicine, pharmaceutical, perfumery, cosmetics and several other industries. There are over 80 spices grown in different parts of the world and around 50 spices are grown in India. The spices that India can offer in abundant quantities are pepper, ginger, turmeric, chilli, cardamom, celery, fenugreek, fennel, cumin, dill, coriander, cinnamon, ajowain (bishop's weed), cassia, clove, nutmeg and mace. Major spices of export are pepper, cumin, cardamom, ginger, turmeric and chillies. Other minor spices include ajowain, aniseed, celery seed, caraway, fennel, fenugreek, coriander, garlic, onion, saffron, vanilla etc. Among the spices exported, pepper has the leading position in terms of both quantity and value realised.

Beside this spices have a great potential to be used either for production of natural antibiotics and food preservatives .Almost every spices have some antimicrobial activity against human, food or plant pathogen (table 1). Even spices like turmeric have been used for preservation of organs. They also exhibit antioxidant property. Thus in future extensive research can be done to customise the multi-usage of spices in various fields.

Table 1: Usage of spices, extraction method and antimicrobial property against test organisms

Spice	Extraction method	Bioactive component	Therapeutic property	Test microorganism	References
Turmeric	Turmeric oil, steam distillation	Sesquiterpenes Curcuminoids	Antioxidant, anti-inflammatory, wound healing, anticancer and antiproliferative, antifungal and anti-bacterial activity.	*Staphylococcus epidermidis, S. aureus, Escherichia coli, Salmonella thyphimurium Aspergillus flavus, A. parasiticus*, *Fusarium moniliforme Penicillium digitatum*.	Oshiro et al., 1990 Shalini J et al., 1992 Ghatak A et al., 1991; Chang H et al., 1987; Ranbir Singh et al., 2002; Jayaprakasha, G. K, 2001
	Ethanol extract	Curcumin	Anti- parasitic	*Entamoeba histolytica* *Plasmodium falciparum*	Koide, T et al., 2002 Rasmussen, H. B et al., 2000
Black pepper	Aqueous and ethanolic extracts	Piperine	Asthma, chronic indigestion, colon toxins, obesity, sinus, congestion, fever intermittent fever, cold extremities, colic, gastric ailments and diarrhoea	Penicillin G resistant strain of *S. aureus*, *B.cereus* and *B. subtilis. Aeromonas hydrophila* , *Alcaligenes* sp, *Citrobacter* sp, *Enterobacter aerogenes*, *E. coli*, *Flavobacterium* sp., *Klebsiella ozaenae*, *K. pneumoniae* , *Micrococcus roseus*, *Plesiomonas shigelloides, Pseudomonas aeruginosa, S. aureus, Streptococcus* sp	Ravindran, 2000 Ao et al., 1998 Perez and Anesini, 1994 Singh et al., 2005 Nazia Masood Ahmed Chaudhry and Perween Tariq, 2006
Basil	Essential oil-steam distillation Ethanol extract	Linalool,methylchavikol methylcinnamat and linolen	Cough treatment, inflammations, dyspepsia, aches and pains.	*Aspergillus ochraceus Staphylococcus, Enterococcus, Pseudomonas* *S.aureus, Bacillus sp and Salmonella typhi*	McClatchey, 1996, Basilico and Basilico, 1999; G. Opalchenova et al., 2002 Bishnu joshi et al., 2009
Black cumin	Essential oil	36-38% fixed oils, proteins, alkaloids, saponin and 0.4 - 2.5% essential oil	Carminative, diuretic, lactagogue and vermifuge	*Aeromonas hydrophila*	Akgul, 1989; Ali and Blunden, 2003 Ali and Blunden, 2003 Muhammet Arici, 2005

Coriander	Aqueous decoctions and infusion	Flavonoids -quercitin, kaempferol, rhamnetin, and epigenin. Phenolic acid -caffeic and chlorogenic acid. 2E-alkenals and alkanals	Anti-diabetic, anti-inflammatory cholesterol-lowering effects, carminative, diuretic, tonic, stimulant, stomachic, refrigerent, aphrodisiac and analgesic	*Salmonella choleraesuis*	Gray and Flatt, 1999 Chithra and Leelamma, 1999 Isao et al., 2004
Cardamom	Ethanol extract	α-terpinyl acetate	Digestive aid, and for the treatment of intestinal gas	*M. smegmatis, K. pneumoniae, S. aureus, E. coli , S. typhimurium , E. faecalis ,M. luteus* and *C. albicans*	Sema Agaoglu, 2005
Fenugreek	Aqueous extract	Rich in lysine, tryptophan, fibre	Health-promoting herb	*Fusarium. graminearum*, *Alternaria* sp. and R*hizoctinia. solani*	R. Haouala et al., 2008
Bay leaf	Essential oil n-hexane	1,8-Cineole	To treat neuralgia and intestinal cramps, digestive aid Cytotoxic activity	*Salmonella enterica* and *E. coli*	Friedman et al.2002 Kivcak and Mert, 2002 Diaaz-Maroto, 2002
Fennel	Essential oil	Tocopherols, Flavonoids	Anti-inflammatory, analgesic, carminative, diuretic and antispasmodic	*E. coli and B. subtilis,* and*, A. niger, Fusarium solani* and *Rhizopus solani*.	M Oktay et al., 2003 Farooq Anwar et al., 2009
Garlic	Alcoholic extracts, lyophilized powders, steam distilled oil	Allicin	Reduces cholesterol, high blood pressure. Heart disease, stomach and colon cancer.	*Aeromonas caviae ,A. hydrophila ,A. sobria, Chromobacterium violaceum, Escherichia coli ,Enterobacter faecalis, Klebsiella pneumonia,Proteus mirabilis, Pseudomonas aeruginosa, Salmonella mgulani,S. typhi, S. roan ,S. senflenberg,S. thyphimurium,S. weltevreden ,Bacillus subtilis* and *S.aureus*	Srinivasan Durairaj et al., 2009
Ginger	Ethanol extract	oleoresin-gingeroles, shogaols and zingerone	Antihyper-cholesterolemic, antihypertensive, antihyperglycaemic, anti-spasmodic, aperients, alexeteric, circulatory stimulant, counter irritant, sialagogue, vasodilator effects.	*E. coli, S.aureus* and *Bacillus* sp	Onyeagba R.A et al., 2004 M. Yusha'u et al., 2008
Mustard	Aqueous extract	Allyl isothiocyanate	Pain remedy, stimulate the appetite and induces vomiting	mycotoxic *Aspergillus, Pseudomonas*	Azzouz, M. A. and Bullerman, L. R., 1982; Sandra G et al., 1998
Cinnamon	Essential oil Alcoholic extract	cinnamaldehyde	Promote blood circulation	*Streptococcus oralis, S. anginosus*, *S. intermedius* and *S. sanguis*, *Enterobacter aerogenes* and *Micrococcus roseus* *B. megaterium* and *E. faecalis*	N.M.A Chaudry and Perwain Tariq, 2006 D. Ayfer Ates et al ., 2003
Star anise	Ethanol extract	Trans -anithole	medicines	*Aspergillus niger*, *Candida albicans*, *Microsporom canis* and 4 mg/ml for *Epidermaphyton fluccosum* and *Trichophyton mentagrophytes*	Yazdani D et al., 2009

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