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 and as noteworthy as medicines and perfumes. No country in the world cultivates as a lot of kinds of spices as India with quality and as noteworthy as medicines and perfumes. No country in the world cultivates as a lot of kinds of spices as India with quality and as noteworthy as medicines and perfumes. No country in the world cultivates as a lot of kinds of spices as India with quality and as noteworthy as medicines and perfumes. 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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 morbillorum*, *Streptococcus mutans* and *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 Lakhmi, 2009).

**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 holiest 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%), m-cinnammat (7.24%) and linalol (0.14%). (G. Opalchenova et al., 2002)

The crude aqueous extract was active against *Neisseria gonorrhoea* (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 (Bishnoi 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 Aric, 2005).

**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 beneficial phytoneutrients including carvone, geraniol, limonene, borneol, camphor, elemol, and linalool. Coriander’s flavonoids include quercitin, kaempferol, rhamnetin and epigениn. 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%. n-terpinyl acetate is present in cardamom around (20-50%).

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 Agaoğlu, 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 nutritional profile. It is high in the amino acids lysine and tryptophan, fiber and rare constituents that give it its extensive nutritional profile. It is high in the amino acids lysine and tryptophan, fiber and rare constituents that give it its extensive nutritional profile. It is high in the amino acids lysine and tryptophan, fiber and rare constituents that give it its extensive nutritional profile.

**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 decocation of bay leaf were sensitive to Streptococcus intermedius, Salmonella typhi, Pseudomonas aeruginosa, Micrococcus roseus, Escherichia coli, Flavobacterium sp. Klebsiella ozaenae, Klebsiella pneumoniae, 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 (Diaa-El-Mal, 2002). The presence of linalool, R-terpinyl acetate, and several monoterpenic hydrocarbons such as α-pinene and sabine 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 SPF2, 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 possess 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 allin, is equivalent 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 pneumoniae, Proteus mirabilis, Pseudomonas aeruginosa, Salmonella mguani, S. typhi, S. roan, S. senftenberg, 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.

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-gingerol, shogaols and gingerone. 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 ethanol 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 nigra (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 CH3=CHCH2NCS).

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 2366) > 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 are more in essential oils than aqueous decoction and infusion because cinnamaldehyde 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. megarum 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. Anisole is the bioactive component. The ethanol extracts of *I. verum* fruits showed MIC at 16 mg/mL concentration for Aspergillus niger, Candida albicans, Microsporum canis and 4 mg/mL for Epidermaphyton flavus and Trichophyton mentagrophytes. The Minimum Fungidal 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, ajowan (bishop’s weed), cassia, clove, nutmeg and mace. Major spices of export are pepper, cumin, cardamom, ginger, turmeric and chillies. Other minor spices include ajowan, aniseed, celery seed, caraway, fennel, fenugreek, coriander, garlic, onion, saffron, vanilla etc.

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

<table>
<thead>
<tr>
<th>Spice</th>
<th>Extraction method</th>
<th>Bioactive component</th>
<th>Therapeutic property</th>
<th>Test microorganism</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol extract</td>
<td>Curcumin</td>
<td>Anti-parasitic</td>
<td>Entamoeba histolytica</td>
<td>Plasmodium falciparum</td>
<td>Koide, T et al., 2002; Rasmussen, H. B et al., 2000</td>
</tr>
<tr>
<td>Black pepper</td>
<td>Aqueous and ethanolic extracts</td>
<td>Piperine</td>
<td>Asthma, chronic indigestion, colon toxins, obesity, sinus, congestion, fever, cold extremities, colic, gastric ailments and diarrhea</td>
<td>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, Pseudomonas aeruginosa, S. aureus, Streptococcus sp</td>
<td>Ravidran, 2000; Ao et al., 1998; Perez and Aanesin, 1994; Singh et al., 2005; Nazia Masood Ahmed Chaudhry and Perween Tariq, 2006</td>
</tr>
<tr>
<td>Basil</td>
<td>Essential oil-steam distillation; Ethanol extract</td>
<td>Linalool, methylchavikol, methylcinnamat and limonen</td>
<td>Cough treatment, inflammation, dyspepsia, aches and pains.</td>
<td>Aspergillus ochraceus, Staphylococcus Entero coccius, Pseudomonas</td>
<td>McClatchey, 1996; Basilio and Basili, 1999; G. Opalcherova et al., 2002</td>
</tr>
<tr>
<td>Black cumin</td>
<td>Essential oil</td>
<td>36-38% fixed oils, proteins, alkaloids, sap 0.1 - 2.5% essential oil</td>
<td>Carminative, diuretic, lactagogue and vermifuge</td>
<td>Aeromonas hydrophila</td>
<td>Akgul, 1989; Ali and Blunden, 2003; Ali and Blunden, 2003; Muhammet Arici, 2005</td>
</tr>
<tr>
<td>Plant</td>
<td>Preparation</td>
<td>Constituents</td>
<td>Medicinal Actions</td>
<td>References</td>
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</tr>
<tr>
<td>Coriander</td>
<td>Aqueous decoctions and infusion</td>
<td>Flavonoids -quercitin, kaempferol, rhamnetin, and epigенин. Phenolic acid -caffeic and chlorogenic acid, 2E-alkenals and alkanals</td>
<td>Anti-diabetic, anti-inflammatory cholesterol-lowering effects, carminative, diuretic, tonic, stimulant, stomachic, refrigerent, aphrodisiac and analgesic</td>
<td>Gray and Flatt, 1999; Chithra and Leelamma, 1999; Isao et al., 2004</td>
<td></td>
</tr>
<tr>
<td>Cardamom</td>
<td>Ethanol extract</td>
<td>α-terpinyl acetate</td>
<td>Digestive aid, and for the treatment of intestinal gas</td>
<td>M. smegmatis, K. pneumoniae, S. aureus, E. coli, S. typhimurium, E. faecalis, M. luteus and C. albicans</td>
<td>Sema Agaoglu., 2005</td>
</tr>
<tr>
<td>Fenugreek</td>
<td>Aqueous extract</td>
<td>Rich in lysine, tryptophan, fibre</td>
<td>Health-promoting herb</td>
<td>Fusarium graminearum, Alternaria sp. and Rhizoctonia solari</td>
<td>R. Haouala et al., 2008</td>
</tr>
<tr>
<td>Bay leaf</td>
<td>Essential oil</td>
<td>1,8-Cineole</td>
<td>To treat neuralgia and intestinal cramps, digestive aid</td>
<td>Salmonella enterica and E. coli</td>
<td>Friedman et al., 2002; Kivac and Mert, 2002; Diaz-Maroto, 2002</td>
</tr>
<tr>
<td>Fennel</td>
<td>Essential oil</td>
<td>Tocopherols, Flavonoids</td>
<td>Anti-inflammatory, analgesic, carminative, diuretic and antispasmodic</td>
<td>E. coli and B. subtilis, and, A. niger, Fusarium solani and Rhizopus solani</td>
<td>M. Oktay et al., 2003; Farooq Anwar et al., 2009</td>
</tr>
<tr>
<td>Mustard</td>
<td>Aqueous extract</td>
<td>Allyl isothiocyanate</td>
<td>Pain remedy, stimulate the appetite and induces vomiting</td>
<td>mycotoxic Aspergillus, Pseudomonas</td>
<td>Azzouz, M. A. and Bullerman, L. R., 1982; Sandra G et al., 1998</td>
</tr>
<tr>
<td>Cinnamon</td>
<td>Essential oil</td>
<td>cinnamaldehyde</td>
<td>Promote blood circulation</td>
<td>Streptococcus oralis, S. argininosus, S. intermedius and S. sanguis, Enterobacter aerogenes and Micrococcus roseus, B. megaterium and E. faecalis</td>
<td>N.M.A Chaudry and Perwain Tariq, 2006</td>
</tr>
<tr>
<td>Star anise</td>
<td>Ethanol extract</td>
<td>Trans -anithole</td>
<td>medicines</td>
<td>Aspergillus niger, Candida albicans, Microsporum canis and 4 mg/ml for Epidermaphyton, Flucosum and Trichophyton mentagrophytes</td>
<td>Yazdani D et al., 2009</td>
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**References**


