

# Antimicrobial Phytochemicals from Indian Spices and Herbs



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## Abstract

Indian spices and herbs possess a large number of medicinal values, mainly antimicrobial activities. Indian spices are used for the preservation of food and also used as household medicine. In this review, some of useful effects of phytochemicals from different herbs and spices on micro-organisms are described. Micro-organisms cause many infectious diseases in human and also spoils the food. Micro-organisms are threat for the human all over the world. The efficacy of synthetic antimicrobial agents to prevent micro-organisms that cause disease have been decreased by the evolution of resistance among microbes. So, there is an urgent need to discover the new antimicrobial agents which can overcome such resistance. Many spices like Garlic, turmeric, coriander, clove, oregano, cinnamon and thyme have substantial antimicrobial activity against microbes like vibrio parahaemolyticus, Staphylococcus aureus, Bacillus subtilis and Pseudomonas fluorescens. So, spices have emerged to have great potential to discover as safe and new antimicrobial agents.

**Keywords:** Antimicrobial Agents, Spices, Turmeric, Garlic, Bacillus Sublitis, Staphylococcus Aureus, Pseudomonas Fluorescens.

## Introduction Microbes

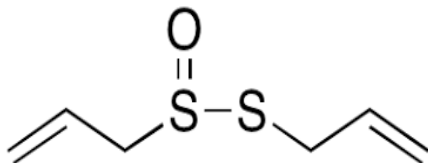
Micro-organisms include virus, bacteria, fungi and protists. They are the causative agents of variety of communicable diseases. Many antimicrobial medicines have developed for curing the human beings from these microbes. Antimicrobials are typically liquid and these liquid inhibit the growth of the bacteria, protozoans and fungi. Many micro-organisms are increasing the resistance against multiple antibiotics so many researchers are trying to develop new effective antimicrobial reagents which are free of resistance and cost. In food preservation, new technologies are emerging which are reducing the effect of preservatives and promoting the use of antimicrobials of plants. So many spices extract also used in antimicrobial activity. We mainly have been using spices for many centuries to enhance flavour and aroma of our foods as well as our ancestors also used spices for food preservation and in clinical ailments. At present close to 80 % of world population is based on botanical preparation as medicine for better and effective treatment against ailments. Phytochemicals or Secondary metabolites are compounds that provide unique flavour and aroma to spices and herbs. Most phytochemicals are antimicrobial substances.

## Some Classes of Phytochemicals

1. Isoflavones
2. Flavonoids
3. Anthocyanins

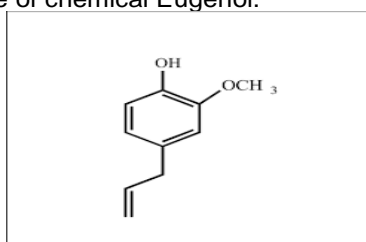
These phytochemicals are associated with the spices and herbs. Benzene functional group is responsible for the antimicrobial activities present in phytochemicals derived from the spices and herbs. Sulfur also plays a significant role in the antimicrobial property of some spices. Here we are describing some of the spices and herbs which are used as antimicrobial agents. Black pepper due to its physiological and antimicrobial benefits, highly used in folk medicine, particularly in muscle aches, treating pain, the flu and rheumatism. In recent studies it has been shown that extract of black pepper can inhibit food pathogens and food spoilage. Garlic is used since centuries due to its beneficial effects on the anti-inflammatory, anticancer, antibiotic, cardiovascular system, hypoglycemic, and hormone-like effects. Antimicrobial activity and pungent odor of garlic depend on allicin and allicin compound formed by chopping and crushing the garlic. Allicin provides antioxidant benefits and helps in

reducing the inflammation. Allicin is slightly yellow, oily liquid. Allicin also known as allylthiosulfinate.



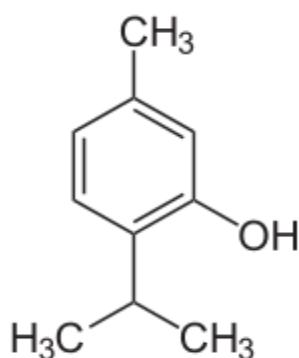
Structure of Allicin

Clove is also used for the antimicrobial effect. The oil extracted from clove is mainly used for aromatherapy when stimulation and warming is needed in digestive diseases and also used in dental surgeries as a pain killer. Clove has antimicrobial activity due to the presence of chemical Eugenol.



Structure of Eugenol

Turmeric contains a phytochemical called curcumin. Curcumin is insoluble in water but soluble in ethanol and acetone. Biological activities of turmeric is controlled by the curcumin and it is most soothing and bioactive component of the turmeric and have the properties like the antioxidant, anti-inflammatory and cholesterol-lowering. Oregano is a herb which is used as aromatic oil and supplements in diet. The antioxidant carvacrol, thymol, ocimene, etc. give the scent and flavor to the oregano. Antioxidant like thymol and carvacrol of oregano are mainly responsible for the antibacterial effect.



Structure of Thymol

Thyme is a herb which is also used for the antimicrobial properties. It is a herb with ornamental, medicinal and dietary uses. Thyme was used by the people to protect from black death (Plague is a disease caused by the bacteria which is famous for causing many deaths due to a widespread epidemic in Europe, in 14<sup>th</sup> century. Many references showed the

illness that referred to as a "pestilence in the air" or Black Death).

Cinnamon is a spice incurred from the inner bark of many tree species. Cinnamon is not only used for flavouring the food and aromatic condiment but also used as anti-inflammatory, antibacterial agent. It also reduces the risk of disease related to the heart.

Thus herbs and spices do not only flavor the food but have many medicinal values. As these are natural products so attracted many researchers used them as antimicrobial agents against the bacteria and pathogens.

#### Aim of the Study

To explore various photochemicals from Indian Spices and Herbs

#### Review of Literature

Plants have immense potential for their use as curative medicine. India has about 4.5 million plant species among them, several thousands have been arrogate to own medicinal properties against human diseases. As a outcome, the pharmacological function of many medicinal plants has been studied, even though the huge majority of medicinal plants remain to be studied for their pharmacological effects and phytochemical components. It has been reported that Ginger, Garlic, Black Pepper, Clove and Green Chillies shows antimicrobial activity but among all the spices garlic showed the more antimicrobial activity. Antibacterial activities of *Curcuma longa* rhizome extract against gram negative and gram positive bacteria are reported. Essential oil was observed most active and its effect was compared with the standard antibiotics like ampicillin, gentamycin, erythromycin and doxycycline in these strains. *S. aureus* showed more sensitivity to essential oil than the standard strains. The use of essential oil from turmeric as a potential antiseptic in prevention and treatment of antibacterial infections has been suggested. Bin Shan, et al; (2007) reported antimicrobial activity of 46 extracts from medicinal and dietary spices against 5 bacteria by using Agar-well diffusion method. And the total phenolic amount of spices was also evaluated. Many spices and herbs were found to have high content of phenolic compounds and had good antibacterial activity. Gram negative bacteria were less sensitive than gram positive bacteria to the sample extracts. (Bin Shan et al; 2007).

Biljana Bozin, et al; (2007) reported the antimicrobial activity of essential oil of sage and rosemary with the help of mass spectrometry and gas chromatography. 13 bacteria and 6 fungi were taken as sample against which antimicrobial activity is tested. Essential oil of rosemary had also a significant antifungal activity (Biljana Bozin, et al; 2007). Antibacterial activity of ginger, pepper and garlic extracts has been evaluated against *Klebsiella pneumoniae*, *Morganellamorgani*, *Staphylococcus aureus*, *Escherichia coli* and *Proteus vulgaris*. Hediati M.

H. Salama and co-workers (2010) evaluated that the phytochemical studies revealed the presence of tannins, saponins, flavonoids, alkaloids and sesquiterpenes and the extracts were active against both gram negative and gram positive bacteria. They used *Polygonum aviculare* to test the antimicrobial activity against bacteria. They extracted air dried powder by using organic solvent like ethanol, chloroform, acetone and water. They used disc diffusion method for testing the antimicrobial activity. Extract of chloroform gave best result of antimicrobial activity against all fungi and bacteria except the *Candida albicans* fungi. (Hediat M. H. Salama et al; 2010).

Ramkumar Pundir and Pranay Jain (2010) reported that Turmeric ethanolic showed antifungal activity against *Rhizopus stolonifer* and *Mucor* in Mycelium growth. Aqueous extract of black pepper did not show any antibacterial activity against *B. subtilis*. Aqueous extract of black pepper and turmeric showed antibacterial activity against *Staphylococcus aureus*. Agar well diffusion method was used to test the antimicrobial activity and poisoned food technique for testing the antifungal activity (Ramkumar Pundir and Pranay Jain, 2010). Jha Harit et al; (2013) studied the antimicrobial activity of rhizome of selected *Curcuma* variety. The results showed that the ethanolic extract of plants have more potential to inhibit test pathogenic bacteria and fungi than aqueous plant rhizome extract. The agar well diffusion method was used for testing the antimicrobial activity. To know the efficiency standard drugs like fluconazole and tetracycline were used for comparison to determine the zone of inhibition of extract. (Jha Harit et al; 2013).

It has been reported that ethanolic and methanolic extracts of clove showed good inhibitory activity against microbes. Agar diffusion method was used to test the susceptibility of micro-organisms towards the sample spices. Maximum antimicrobial activity of ethanolic extract of *Syzygium aromaticum* was obtained against *Pseudomonas aeruginosa* whereas least in *Staphylococcus aureus*. The metal ions also increased or enhanced the activity of clove sample but to a particular concentration. (Amit Pandey, Parul Singh 2011). Gbonjubola Adeshina, S. Jibo, et al; (2011) reported that except *Staphylococcus aureus* all the bacteria that were investigated were susceptible to the fresh red and white onion juices but were not susceptible to the fresh ginger juice. (Gbonjubola Adeshina, S. Jibo, et al. 2011). Antibacterial effects of *Allium sativum*, *Punica granatum* and *Citrus limon* against bacteria isolated from the spoiled food have been reported, All the plants showed antibacterial activity against the bacteria but *Punica granatum* extract showed the most various effect. (Vipul Varma, Rachana Singh, et al; 2012).

F. Darugheet et al; (2012) reported the antioxidant and antifungal activity of *Coriandrum sativum* cake. Extraction of essential oil is done by steam distillation. Cakes were formed by sugar, soybean oil and salt. The results indicated that Coriander essential oil inhibited the rate of primary and secondary oxidation products formation in cake and their effects were almost equal to BHA. (F. Darugheet et al; 2012).

Atheer Abdul hameed Khasham (2014) observed the antibacterial activity of Garlic extract against *Staphylococcus aureus*. Result showed that the diameters of the inhibition of the growth of bacteria increased with increasing of the concentration of alcoholic extract. (Khasham, A.A., 2014). Kamrul Islam, Asma Afroz Rowsni, et al; (2014) reported that antimicrobial activity of ginger extraction with soybean oil. They tested the antimicrobial activity of ginger against 24 microbes including *E. coli*, *S. aureus*, *Salmonella* and *V. cholerae*. They studied that ginger extract showed potent antimicrobial activity against bacterial pathogens. And ginger extract showed more zone of inhibition for gram negative bacteria and for *Staphylococcus aureus* showed lower zone of inhibition. (Kamrul Islam, Asma Afroz Rowsni, et al; 2014). Dinesh Maharjan, Anjana Singh, et al. (2014) reported that essential oil of cinnamon showed maximum forbiddance against all bacteria while essential oil of clove and ajowan inhibited 70% and 90% bacteria respectively. Antimicrobial effects were tested by using the agar well diffusion method. (Maharjan, D., Singh, A., et al; 2014). S. Bhat et al; (2014) studied the Coriander: Processing, nutritional and functional aspects. Aliphatic-alkanals and alkenals characterized from the fresh leaves of the Coriander were found to possess bactericidal activity against *Salmonella choleraesuis*. (Bhat, S., et al; 2014). Bhawna Pandey, Shabina Khan, et al; (2014) observed the antimicrobial activity of some Indian spices like Turmeric, Ajwain, Clove, Black pepper and Dalchini against two bacteria *Staphylococcus aureus* and *Klebsiella pneumonia*. They used the methanol and acetone extract of the spices and reported that extract of methanol from spices have more antimicrobial activities equivalence to extract of acetone from spices. (Pandey, B., Khan, S., et al; 2014). Yashab Kumar, Abhinav Srivastava, et al; (2014) reported the antibacterial activity of garlic and clove against *S. aureus* and *B. cereus*, *E. coli* and *S. typhi* at different concentration of extract. Spices samples were taken from the market and then sterilized by 0.1%  $HgCl_2$ . After sterilization the spices were crushed in mortar and pestle with distilled water and then the sample was transferred in centrifuge tubes which are already sterilized. The effect was tested by the filter paper method. Clove was found less effective than garlic. *E. coli* was found most resistant while *B. cereus* was most sensitive. (Kumar, Y.,

Srivastava, A., et al; 2014). H.G. Shete and M.P. Chitanand (2014) reported that alcoholic extract of black pepper and clove showed uttermost activity against gram positive bacteria and alcoholic extract of black pepper and star anise showed uttermost activity against gram negative bacteria. (Shete, H.G. and Chitanand, M.P., 2014). Seyed Fazel Nabavi, Maria Daglia, et al; (2015) reported the traditional uses, history, clinical impact and phytochemical constituents of cinnamon. As herbs and spices used as antimicrobial agent and now-a-days these are also used in industry of cosmetic. They reported that cinnamon mainly cultivated in China, Srilanka, Madagascar and Seychelles. It is also cultivated in Vietnam and India. They reported that cinnamon is used as anti-diabetes and also helps in lowering the glucose level. They also reported the antimicrobial effects of cinnamon against many bacterias with the help of disk-diffusion method. And cinnamon showed good antimicrobial effects against the bacteria. Authors also obtained essential oil from the bark of cinnamon by the method of hydro-distillation and tested its antibacterial activity against *S. aureus*, *E.coli*, etc. and analysed the effect with the help of thin layer chromatography. The results were obtained were excellent. (Seyed Fazel Nabavi, Maria Daglia, et al; 2015).

Ranganthan Kapilan (2015) reported that alcoholic extract of clove, lemongrass and cardamom revealed uttermost antimicrobial activity against gram negative bacteria but alcoholic extract of lemongrass showed uttermost antimicrobial activity against gram positive bacteria. Extract was prepared by coarsely and air-dried matter of spices in Soxhlet apparatus with distilled water and after filtering the extract was used for the study in form of aqueous extract. Similarly methanol and ethanol extract was also prepared and nutrient broth was formed. Culture of microbes were done or maintained on nutrient agar. (Kapilan, R., 2015). Hanene Miladi, et al; (2016) reported efflux pump inhibitors and antibacterial effect of carvacrol and thymol against foodborne and clinical pathogens. Results showed that bacterias were sensitive to thymol and carvacrol. And thymol showed best result in comparison to carvacrol against sample pathogens. And the combination of thymol and carvacrol showed excellent antimicrobial activity. (Hanene Miladi, et al; 2016). Qing Liu, Xiao Meng, et. al. (2017) reported that many spices as oregano, cinnamon, thyme, cumin and clove have significant antifungal antibacterial against bacteria, pathogen and fungi like *Pseudomonas fluorescens*, *Vibrio parahaemolyticus* and *Aspergillus flavus* respectively. (Qing Liu, Xiao Meng, et. al. 2017).

Yassine El Atki, Imane Aouam, et al; (2019) reported the antibacterial activity of essential oil and with combination of antibiotics drug-resistant bacteria *S.aureus*, *E.coli* and *P. aeruginosa*. They observed the effect with agar

disc diffusion. The synergistic interaction was noticed against *S. aureus* with chloramphenicol or ampicillin and cinnamon essential oil. And against *E. coli* when chloramphenicol is added with essential oil of cinnamon while the combination of streptomycin and essential oil showed the effect on all the bacterial strains. The combination of antibiotics and essential oil of cinnamon may be used as mutually exclusive therapeutic application that can lower the minimal effective dose of drug, so decreasing the adverse effect and costs of treatment. (Yassine El Atki, Imane Aouam, et al; 2019).

### Conclusion

Spices inhibit activity of bacteria, fungus and pathogens by mitochondrial destruction, disruption of plasma membrane, morphology alteration, nuclear membrane folding, cytoplasm lacking and cell wall thickening caused by spices chemical components that show spices alter the growth and activity of microbes. It has been noticed that chemical compounds with an aldehyde group or hydroxyl group tend to possess potent antimicrobial activity. Spices or herbs have been revealed as potent antimicrobial agents therefore should be used properly. The use of spices in dentistry should be based on evidence of effectiveness and safety. The antimicrobial effects could be raised if active ingredients are refined and efficient dosage driven for relevant administration. The present outcomes, hence, offer up a scientific basis for traditional use of spices.

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