DOI: *10.15613/fijrfn/2017/v4i2/167622*
ISSN (Print) : 2349-8897
***FoodSci*: Indian Journal of Research in Food Science and Nutrition,** *Vol 4(2), 54-59, July-December 2017* *ISSN (Online) : 2350-1006*

Antimicrobial Activity of Commonly used Indian Spices: A Review Article

T. Sivapriya[1*] and Sheila John[2]

[1]Assistant Professor, Department of Home Science, SDNB Vaishnav College, Chrompet, Chennai – 600044, Tamil Nadu, India; sivaamanick@gmail.com
[2]Head and Associate Professor, Department of Home Science, Women's Christian College, Chennai – 600006,, Tamil Nadu, India

Abstract

Herbs and spices could be considered as authentic "functional foods". They are used as medicines from traditional times. Spices are obtained from any part of a plant, from the seeds, leaves, barks, rhizomes, latex, stigmas, and floral buds. Recent researchers are focusing much on these culinary treasures to prove them as a functional food so that when consumed, can help in preventing diseases as well as to cure the existing ailments by providing phyto nutrient rich antioxidants. Phytochemicals in spices, which primarily serve in plant protection, are considered as boon of the 21st Century having less adverse effects when compared to modern drugs. This review article portrays some recent scientific findings about the antimicrobial activity of ginger, pepper, garlic, cloves, turmeric, nutmeg, cinnamon, chilli, tamarind and black mustard which are the commonly used spices that find a place in our day today life and have a distinct place in folk medicine in several of Asian countries.

Keywords: Antimicrobial Activity, Drug Resistant Pathogens, Spices

1. Introduction

"Infectious diseases know no boundaries. Antibiotic-resistant infectious diseases are especially promiscuous and increasingly cause critical global problems. Resistant pathogens continue to pose increasing therapeutic challenges"[1]."Antibacterial resistance associated infections are known to increase morbidity and mortality. The cost of treatment makes the community to unavail treatment and places them at higher risk of infections. In high-income countries, where the burden of infectious diseases is relatively modest, resistance to first-line antibacterial agents is usually overcome by the use of second and third-line agents. In case of developing countries, the burden of infectious diseases is high; the patients with antibacterial-resistant infections maybe unable to obtain or afford effective second-line treatment"[2]. "The situation is aggravated by poor hygiene, unreliable water supplies, and increasing numbers of immune compromised people, which facilitate both the evolution of resistant pathogens and their rapid spread in the community. The development of resistance to antimicrobials by microorganisms is a natural evolutionary response and to be expected. The effective life span of an antimicrobial agent lies in the gap between the development of the new drug and the establishment of widespread resistance. Resistance to antibiotics continues to progress, but the development of new antibiotics, particularly new classes of antibiotics, has stalled. There are antivirals and antifungals in development, but there have been no new classes of antibiotics discovered since the late 1980s"[3].

2. Alternative Treatment Options - Plant Derived Antimicrobials

"Egyptians, Chinese, and Indians are using antimicrobial compounds derived from plant sources for

*Author for correspondence

centuries. Since ancient times, Indians used spices and essential oils from spices such as cinnamon, clove, mint, garlic, and ginger in alternative health remedies. Spices and their constituents are generally recognized as safe (GRAS) and approved by several regulatory agencies such as US Food and Drug Act, the European Union standards, Codex Alimentarius, and Food Safety and Standards Authority of India. In India, the trend of consumption of spices and herbs in food or using them as medicine aims to maintain proper sanitation, health, and hygiene and to increase longevity of life"[4].

Several spices such as clove, ginger, black pepper, cumin, and asafoetida are commonly used in the Indian diet. Scientific literatures have cited the work of several authors on the anti-microbial activity of plants against wide range of bacteria, yeasts, and moulds.

"Spices and herbs, owing to their natural origin, attract more attention of consumers owing to fewer side effects, easier availability and affordability. Adverse effects caused by antibiotics are damage to the intestinal flora, local inflammation, damage to liver and kidney, dysentery, and bone marrow depression"[5]. "Several plant extracts have gained momentum in recent years due to their bioactive principals and formed the basis of pharmaceutical and food processing industries"[6].

This review goes over some relevant research that has already been done in this area. In addition, it lays the ground for the new research that is emerging for nutrient content, and for antimicrobial activities of spices against numerous human pathogens.

2.1 Ginger

"Ginger (Zingiber officinale) is a medicinal plant that has been widely used all over the world, since antiquity, for a wide range of ailments including arthritis, cramps, rheumatism, sprains, sore throats, muscular aches, constipation, vomiting, hypertension, indigestion, and infectious diseases"[7]. "Ginger has direct anti-microbial activity and thus can be used in treatment of bacterial infections"[8].

"Some of the active ingredients present in ginger include terpenes and oleoresin. Ginger also constitutes volatile oils approximately 1% to 3% and non-volatile pungent components oleoresin. The major identified components from terpene are sesquiterpene hydrocarbons and phenolic compounds which are gingerol and shogaol and lipophilic rhizome extracts, yielded potentially active gingerols, which can be converted to shogaols, zingerone, and paradol"[9].

"The antimicrobial activity of dried ginger powder was demonstrated using agar diffusion assay, against food borne pathogens including *Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus, Vibrio cholerae, Klebsiella spp.* and *Salmonella spp*. The result showed the potent antimicrobial activity of the ginger extract against all the tested bacterial pathogens. Extract of ginger showed highest zone of inhibition (11.67±1.53mm) against *Salmonella spp*. and lowest zone of inhibition (8.0±1.73mm) against *Escherichia coli*"[10].

2.2 Pepper

"Pepper plant (*Nigella sativa*) has been reported to have significant activity against many disease conditions such as pancreatic cancer, asthma, bronchitis, and coughing. Various part of the plant has been used in traditional medicine, such as seeds and fruits. *Nigella sativa* seeds are considered as bitter, pungent, aromatic, appetizer, stimulant, diuretic, emmenagogue, anthelmintic, acrid, carminative, digestive, febrifuge, expectorant, purgative, and an abortifacient agent. Seed oil is used as a local anesthetic. The bioactive constituents reported are carvone, Alfa pinene, Beta pinene, sabinene, P- cymene"[11].

"The antimicrobial activity of volatile oil of concentration 20µg has been evaluated by using disc diffusion method. The results of the antimicrobial activity of the *N. sativa* volatile oil were compared with the standard and accordingly, the efficacy of volatile oil was far better than the standard. The data obtained from the study showed that the compound isolated and used for the activity is of high antimicrobial activity against *Escherichia coli, Staphylococcus aureus, Salmonella typhi, Bacillus subtilus, Pseudomonas aeruginosa*. The minimal bactericidal concentration was 125 mg/ml for Escherichia coli, 8 mg/dl for Staphylococcus aureus, and 4 mg/dl for *Bacillus subtilus*"[12].

2.3 Garlic

"Garlic (*Allium sativum*) has been used for centuries worldwide to combat infectious disease. Garlic can be provided in the form of capsules and powders, as dietary supplements, and thus differ from conventional foods or food ingredients. Garlic exhibit a broad antibiotic activity against both Gram-positive and Gram-negative bacteria.

Therapeutic effect of garlic is possible because of its oil- and water-soluble organosulfur compounds, which are responsible for the typical odor and flavor of garlic. Thiosulfinates play an important role in the antibiotic activity of garlic. The antibacterial activity of garlic is also attributed to allicin which interferes with RNA production and lipid synthesis"[13].

"Garlic showed excellent antibacterial activity at all concentrations, (1000, 1500 and 2000 ppm). The maximum effect of garlic extract was shown on *Bacillus cereus* with maximum zone of inhibition and the minimum effect was shown in *Escherichia coli*. On *Bacillus cereus* the maximum zone of inhibition was 27mm at 2000 ppm concentration and Minimum zone of inhibition was 11mm at 1000 ppm concentration. On *Staphylococcus aureus* the maximum zone of inhibition was 24mm at 2000 ppm concentration and minimum zone of inhibition was 10mm at 1000 ppm concentration. On *Salmonella typhi* the maximum zone of inhibition was 19 mm at 2000 ppm concentration and minimum zone of inhibition was 12mm at 1000 ppm concentration and on *Escherichia coli* the maximum zone of inhibition was 16mm at 2000 ppm concentration and minimum zone of inhibition was 8mm at 1000 ppm concentration"[14].

2.4 Cloves

"Cloves (*Syzygium aromaticum*)are used in Ayurveda, Chinese medicine and Western herbalism. Cloves are used as a carminative, to increase hydrochloric acid in the stomach and to improve peristalsis. It is also used in dentistry where the essential oil of clove is used as anadyne for dental emergencies. In addition, the cloves are antimutagenic, anti-inflammatory, antioxidant, antiulcerogenic, antithrombotic and antiparasitic, antibacterial and anti-inflammatory"[15]

"Clove showed maximum effect on *Salmonella typhi* and minimum effect on *E. Coli*. On bacillus cereus the maximum zone of inhibition was 23 at 2000 ppm and minimum zone of inhibition was 9 mm at 1000 ppm concentration"[16].

2.5 Turmeric

"Turmeric (*Curcuma longa*) has a distinctly earthy, slightly bitter, slightly hot peppery flavor and a mustardy smell. Curcumin has been a centre of attraction for potential treatment of an array of diseases, including cancer, Alzheimer's disease, diabetes, allergies, arthritis and other chronic infectious illnesses"[17].

"The most important chemical components of turmeric are a group of compounds called curcuminoids, which include curcumin (diferuloylmethane), demethoxycurcumin, and bisdemethoxycurcumin. There are also other important volatile oils such as turmerone, atlantone, and zingiberene. Some general constituents are sugars, proteins, and resins"[18].

"The antibacterial activity of methanol, chloroform, n-hexane and water extracted turmeric samples was investigated. *Escherichia coli* were susceptible to all the extracts recording different zones of inhibition in these solvents extracted samples. Maximum zone of inhibition (13.5 mm) was noted for *Staphylococcus aureus* by methanol extracted samples when applied at 12 µg concentration followed by methanol recording 11.5 mm zone of inhibition at the same concentration and *Staphylococcus aureus* in water extracted samples applied at 6 and 12 µg concentrations"[19].

"Antimicrobial activity on a wide range of microbes including *Bacillus cereus, Bacillus coagulans, Bacillus subtilis, Staphylococcus aureus. Escherichia coli and Psuedomonas aeruginosa*"[20]."The antimicrobial activity of turmeric is reported to be due to the presence of essential oil, curcumins, curcuminoids, turmeric oil, turmerol and veleric acid"[21].

2.6 Nutmeg

"Bioactive components of Nutmeg (*M*yristica *fragrans*) turmerone and curlone have antioxidant and antimicrobial properties, apart from their traditional use in numerous medical conditions, can offer potential solution in the search for new and natural sources of antioxidants and antimicrobials"[22]. "Studies have shown that nutmeg lowers blood pressure and sooth a stomach ache as well as stop diarrhoea. Nutmeg is known to have anti-inflammatory properties and can be used to treat joint and muscle pain. In holistic medicine it is considered as an excellent liver tonic which removes toxins. Nutmeg oil is also a good herb for kidney, helping in dissolving kidney stones as well as relieves infections"[23].

"*Salmonella* species was found to be the most susceptible having the greatest antimicrobial effect (15 mm) and *K. pneumoniae* followed as the second most affected (12 mm). *Shigella* species was also inhibited by all extracts of nutmeg with the cold-water extracts having

had the greatest effectiveness. A comparison of the average inhibition zone sizes indicated that nutmeg has significant effectiveness as antimicrobial agent against all of the Gram-negative microbes with the greatest effectiveness having been exhibited by the organic extract, acetone, followed by ethanol, and aqueous extract, methanol and then hot water"[24].

2.7 Cinnamon

"Cinnamon (*Cinnamomum zeylanicum)* has promising antibiotic properties. Antimicrobial property is attributed to the terpenoids and phenyl propanoids present in cinnamon. Antimicrobial activity by the mechanism of decreasing the DNA binding activity and by inhibiting transpeptidation enzyme involved in cross linking of polysaccharide chain of bacterial cell wall and also by activating cyclic enzymes"[25].

"Cinnamon extract had an inhibition zone of about 18 mm, against *Escherichia coli* followed by tetracycline which had an inhibition zone of 36mm whereas erythromycin had an inhibition zone of 17 mm. The minimum inhibitory concentration (MIC) value of cinnamon extract was found to be 0.4521 mcg whereas the MIC of erythromycin and tetracycline were found to be 10 mcg and 30 mcg respectively. Although cinnamon powder has a zone of inhibition of 18 mm less than tetracycline, its minimum inhibitory concentration is 0.452 mcg which is higher than tetracycline"[26].

2.8 Chilies

"Chilies (*Capsicum buforum*) are used worldwide in foods for their pungent flavor, aroma, and to prolong food spoilage. With capsaicin contents ranging from zero to millions of Scoville heat units, different varieties offer a wide range of options In addition to their use in cuisines, chili peppers have been explored for their antimicrobial and antifungal properties"[27].

"As new antibiotic-resistant food borne pathogens emerge, the discovery of natural antimicrobials in chili will be invaluable to food scientists. The minimum lethal concentration of the chilli extract was 1.5 ml/100 g on *S. typhimurium*. Capsaicin had strong inhibitory effect starting from 25 mg/ml on Bacillus subtilis"[28].

2.9 Tamarind

Tamarind *(Tamarindus indica*)is a widely used medicinal plant. Its uses are as varied as the cultures that use it. The pulp has been documented in both the British and American pharmacopoeias as anti-pyretic, antiscorbutic, laxative, carminative and remedy for biliousness and bile disorder and the leaves have antihelmintic and vermifuge properties, destroying intestinal parasites.

"The phytochemical constituents detected, including flavonoids, alkaloids, tannins, cyanogenic glycosides and anthroquinones accounted for antibacterial activity. The low pH of the extracts may reflect the presence of high levels of oxalic acid, ascorbic acid and, particularly, tartaric acid which is an unusual plant acid"[29].

"The cold-water extract of the fruit pulp was active against all (100%) of the non-diarrheagenic bacterial strains tested achieving inhibition zone diameters (IZDs) ranging from 18 ± 0.0 mm to 24.5 ± 0.71 mm and minimum bactericidal concentration (MBC) of 125 mg/mL. clinical isolates of *E. coli* from infantile diarrhea and *Pseudomonas aeruginosa* \were specifically tested with the fruit pulp extracts and the results showed the zone of inhibition for *E. coli* as 17.5 mm and for *Pseudomonas aeruginosa* as 20.5 mm"[30].

2.10 Black Mustard

"Black mustard (*Brassica nigra*)seeds contains various health-promoting phytochemicals including carotenoids, phenolic compounds, and glucosinolates. Glucosinolates phytochemical present in Brassica crops are sinigrin, glucobarbarin, and gluconasturtiin These compounds are often associated with their ability to act as detoxifiers against oxidative Mustard oil affects the concentration of intracellular component, such as ATP in bacteria and affects the pH suggesting that cytoplasmic membrane is involved in the antimicrobial action of mustard. Thus, mustard can be used as an effective antimicrobial agent" [31].

"*S. aureus*, *B. cereus and Salmonella* were inhibited by the oil extract of *B. nigra*. There was more inhibition zone of oil extracted by oil extract as compared to the ethanol extract. *Staphylococcus aureus* exhibited a zone of inhibition 22.5mm while *Salmonella typi* showed 19 mm and *Bacillus cereus* showed 25 mm as zone of inhibition"[32].

3. Conclusion

The spread of drug resistant bacteria is one of the most dangerous threats to the effective treatment of infectious diseases. The emergence of multidrug resistance pathogen is becoming a global problem. Prevention seems to be the need to tackle this problem at this juncture. The

attempt to discover new natural therapeutics, has induced scientists all over the world to seek solution from the field of bioactive components from spices.

Down the ages extracts of spices have evoked interest as sources of natural products. They have been screened for their potential use as alternative remedies for the treatment of many infectious diseases. Extracts of spices have been shown to possess antibacterial, antifungal, antiviral, insecticidal, germicidal and antioxidant property.

Thus, the use of spices at appropriate levels can help us to battle against deadly infections which pose a great challenge for the community. It is essential to carry out more scientific experiments on these spices to find a remedy for multidrug resistant pathogens.

4. References

1. Bush K. Introduction to Antimicrobial Therapeutics Reviews. Ann NY Acad Sci. 2014;1323 :v–vi https://doi.org/10.1111/nyas.12541 PMid:25195941
2. Samuel K, Gordon D. Antibacterial resistance in sub-Saharan Africa: an underestimated emergency. Ann. N.Y. Acad. Sci. 2014;1323:43–55 https://doi.org/10.1111/nyas.12380 PMid:24628272 PMCid:PMC4159419
3. Davies SC, Fowler T, Watson J. Infections and the rise of antimicrobial resistance. Annual report of the Chief Medical Officer, Lancet. 2011; 381: 1606–1609. https://doi.org/10.1016/S0140-6736(13)60604-2
4. Nickel JC. Management of urinary tract infections: historical perspective and current strategies.The Journal of Urology. 2005; 173(1): 21–32. https://doi.org/10.1097/01.ju.0000141496.59533.b2 https://doi.org/10.1097/01.ju.0000141497.46841.7a
5. Dhiman R, Aggarwal NK, Kaur M. Comparative evaluation of antimicrobial activities of commonly used Indian spices. Research Journal of Microbiology. 2015; 10:170–80. https://doi.org/10.3923/jm.2015.170.180
6. Sofia PK, Prasad R, Vijay VK, Srivastava AK. Evaluation of antibacterial activity of Indian spices against common foodborne pathogens," International Journal of Food ScienceandTechnology. 2007;42:910–915 https://doi.org/10.1111/j.1365-2621.2006.01308.x
7. Kamrul I, Rowsni A, Murad K. Antimicrobial activity of ginger (Zingiberofficinale) extracts against food-borne pathogenic bacteria. International Journal of Science, Environment and Technology. 2014; 3:867–71
8. Ali BH, Blunden G, Tanira MO, Nemmar A. Some phytochemical, pharmacological and toxicological properties of ginger (Zingiber officinale Roscoe): A review of recent research. Food Chem Toxicol. 2008; 46(2): 409–420. https://doi.org/10.1016/j.fct.2007.09.085 PMid:17950516
9. an BKH, Vanitha J. (2004). Immunomodulatory and Antibacterial Effects of Some Traditional Chinese Medicinal Herbs: A Review. Curr Med Chem. 2004; 11(11):1423–30. https://doi.org/10.2174/0929867043365161 PMid:15180575
10. Arshad HR, Fahad MA, Salah MA. Review Article Active ingredients of ginger as potential candidates in the prevention and treatment of diseases via modulation of biological activities. Int J Physiol Pathophysiol. 2014; 6(2):125–36.
11. Rajsekhar S, Kaldeep B. Pharmocognosy and Pharmacology of Nigella sativa – a Review, IRJP. 2011;2 (11); 36–9.
12. Jyothi SG, Kumar M, Gerige Y, Muralidhara R, Ramanjaneyulu. GC-MS Analysis of Nigella sativa Seeds and Antimicrobial Activity of its Volatile oil, Braz Arch Biol Technol. 2009; 52 (5):1189–92 https://doi.org/10.1590/S1516-89132009000500016
13. Durairaj S, Srinivasan S, Lakshmana P. In vitro Antibacterial activity and stability of garlic extract at different pH and temperature. Electronic Journal of Biology. 2009; 5(1): 5–10.
14. Yashab K, Sakshi A, Abhinav S, Satyaprakash K, Garima A, Mohammad Alam K. Antibacterial activity of Clove (Syzygiumaromaticum) and Garlic (Allium sativum) on different pathogenic bacteria. Int J Pure App Biosci. 2011; 4 2 (3): 305–11
15. Pandey A, Singh P. Antibacterial activity of Syzygium aromaticum (clove) with metal ion effect against food borne pathogens. Asian Journal of Plant Science and Research. 2011; 1(2): 69–80.
16. Joe MM, Jayachitra J, Vijayapriya M. Antimicrobial activity of some common spices against certain human pathogens. Journal of Medicinal Plants Research. 2009; 3(11):1134–6
17. Sundar AR, Samuel JJ, Ranganathan TV, Tiroutchelvam D. A Review – Recent Advances in Nutrition of Health Benefits and their Significance of Indian Spices in Foods. Int J Pure App Biosci. 2014; 2(2): 15–23
18. Pezeshk S, Rezaei M, Hosseini H. Effects of turmeric, shallot extracts, and their combination on quality characteristics of vacuum-packaged rainbow trout stored at 4 ± 1 °C. J Food Sci. 2011; 76:387–91. https://doi.org/10.1111/j.1750-3841.2011.02242.x PMid:21729071
19. Rai D, Singh JK, Roy N, Panda D. Curcumin inhibits FtsZ assembly: an attractive mechanism for its antibacterial activity. Biochem J. 2008; 410:147–55 https://doi.org/10.1042/BJ20070891 PMid:17953519
20. Negi PS, Jayprakash JK, Rao LM Sakarian KK. Antimicrobial activity of turmeric oil. J Agric Food Chem. 1999; 47:4297–300 https://doi.org/10.1021/jf990308d PMid:10552805
21. Basniwal RK, Butter HS, Jain VK, Jain N. Curcumin nanoparticles: preparation, characterization, and anti-

microbial study. J Agric Food Chem. 2011; 59:2056–61. https://doi.org/10.1021/jf104402t PMid:21322563

22. Gupta C, Garg AP, Uniyal RC, Kumara A. Antimicrobial activity of some herbal oils against common food-borne pathogens. African Journal of Microbiology Research. 2008; (2):258–61.
23. Kadhim M, Rana K, Amaal S. Antibacterial Activity of Nutmeg (Myristica fragrans) Seed Extracts Against Some Pathogenic Bacteria. Journal of Al-Nahrain University. 2013; 16 (2):188–92 https://doi.org/10.22401/JNUS.16.2.29
24. Nurhasanah. Antimicrobial Activity of Nutmeg (Myristica fragrans Houtt) Fruit Methanol Extract Againt Growth of Staphylococus aureus and Escherichia coli. Beranda. 2014; 3:1
25. Ranjan S, Nandita D, Ramalingam C. Comparative study of antibacterial activity of garlic and cinnamon at different temperature and its application on preservation of fish. Adv Appl Sci Res. 2012; 3(1) :495–501.
26. Sivapriya T, John S, Iyer PR. Antibiotic Efficacy of Cinnamon (Cinnamon zeylanicum) against Urinary Pathogens in Type II Diabetic Men. Journal of Herbs, Spices & Medicinal Plants. 2014; 20:421–6. https://doi.org/10.1080/10496475.2014.889635
27. Torres MJ, Chavez GA, Chavez RE. Antimicrobial properties of alkamides present in flavouring plants traditionally used in Mesoamerica: affinin and capsaicin. J Ethnopharmacol. 1999; 64:241–8 https://doi.org/10.1016/S0378-8741(98)00134-2
28. Kalia NP, Mahajan P, Mehra R, Nargotra A, and Sharma JP. Capsaicin, a novel inhibitor of the NorA efflux pump, reduces the intracellular invasion of Staphylococcus aureus. J Antimicrob Chemother. 2012; 67:2401–8. https://doi.org/10.1093/jac/dks232 PMid:22807321
29. Raimondi L, Lodovici M, Guglielmi F, Banchelli G, Ciuffi M, Boldrini E, Pirisino R. The polysaccharide from Tamarindus indica (TS-polysaccharide) protects cultured corneal-derived cells (SIRC cells) from ultraviolet rays. J Pharm Pharmacol. 2003; 55:333–8 https://doi.org/10.1211/002235702630 PMid:12724038
30. Halkier BA, Gershenzon J. Biology and biochemistry of glucosinolates. Annu Rev Plant Biol. 2006; 57:303–33 https://doi.org/10.1146/annurev.arplant.57.032905.105228 PMid:16669764
31. Harvey SG, Hannahan HN, Sams CE. Indian mustard and allyl isothiocyanate inhibit Sclerotium rolfsii. J. Am. Soc. Hortic. Sci. 2002, 127, 27–31
32. Kuru P. Tamarindus indica and its health related effects. Asian Journal of Tropical Medicine. 2014; 4(9):676–81 https://doi.org/10.12980/APJTB.4.2014APJTB-2014-0173