Herbs and spices as a potential antimicrobial agents for food application

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ABSTRACT

Synthetic food additives pose serious threat to the consumers regarding food safety (which is a prime demand of the consumers). Herbs and spices as natural foodstuffs are the replacers synthetically formulated additives, leaving safety concern and providing prime quality food products. These naturally occurring additives have been traditionally used as medicine, flavoring agents and for the food preservation. Spices have been regarded as permanent ingredient in household culinary practices and also adopted as a part of daily diets worldwide. They are blessed with numerous functional benefits as their small quantity can enhance flavor and used as naturally antimicrobial agents. Current research unveiled different spices and herbs for their antimicrobial activities and functional effects besides their flavor and fragrance traits. Clove, garlic, cinnamon, rosemary, cumin, oregano, bay, thyme, mustard, basil, pepper, ginger and sage have been reported for their antimicrobial activity against spoilage and pathogenic bacteria along fungi Staphylococcus spp., Escherichia spp., Listeria spp., Pseudomonas spp., Aspergillus spp., Cladosporium spp. and Salmonella spp. Type of microorganism, nature of food product, type of spices essential oils and extracts determine the potential of antimicrobial activity.

Keywords: Plant extract, essential oil, spices, herbs, antimicrobial activity

INTRODUCTION

Spices are to be defined as any flavor imparting aromatic plant substance which is meant for the seasoning than nutrition. It adds savor or spiciness to the food products or drinks. Historically spices have been used preserving the foods products since decades. The essential oils having phytochemicals are good source of natural antimicrobial agents. Egyptians adopted herbs and spices in their daily food. These traditional items were ascended down to the Asian region including China, India and Pakistan. Different spices (clove, ginger, cinnamon, mint and garlic) are utilized as nutraceutical and for the remedy of different diseases (Kordali et al., 2005).

In the ancient history about in 200 BC, Chinese used these spices to refresh their breath during their conversation with the emperor for their good sake and also to remove the off odor. The extracts and essential oils having secret constituents that acts to inhibit the microbial growth and prevent the deteriorative activities. Spices and herbs have also played role in the dramatic uphill of the civilization in the account of nations. The palatability of different dishes is enhanced by the spectacular aroma and tanginess of spices and herbs. Pharmacological and nutraceutical based industry is thoroughly relaying on the herbs and species for the preparation of numerous medicines. These are helpful to the cure of different disease as ginger is proven handful for the treatment of the cancer and different nervous system related diseases. Sensory attributes of the product (Flavor, color and taste) are improved and off-odors are masked by the species. Secret ingredients for these characters are the volatile oils and oleoresins (Proestos et al., 2008).

Conventionally used spices include clove, cinnamon bark, dill seed, coriander seed, garlic, licorice root, ginger root, mint oil, paprika, onion, parsley herb/root, peppermint leaf and oil, thyme, rosemary, sage, white mustard seed and turmeric root. Dyspepsia and gastrointestinal disturbances are mainly cured by these herbs and spices (Silva et al., 2007). Food pathogens are a big trouble for food handlers as they deteriorate and spoil the food. The antimicrobials have been incorporated in the food products due to following concerns: (1) to enhance food preservation by controlling food spoilage microorganisms (2) to hinder or suppress pathogenic microbes (food safety). There are different sources of naturally derived antimicrobials such as plants, animal and microbes. The effectiveness of the essential oils was reported by different scientists and
it was found that the oregano is the most effective essential oil against food pathogens. The least effective oil was recorded for cilantro against pathogens. These are regarded as natural antimicrobial agents used for the preservation of food products (Burt, 2004).

The shelf life of the semi-processed and processed food can be extended by reducing the viability or microbes. It’s all due to the application of antimicrobial compounds present in spices and herbs. These antimicrobial properties are helpful not only to improve shelf life but to improve the taste of the product. Herbs and spices have inbuilt self-defense against the pathogenic and infectious microorganisms (Kim et al., 2003). Fresh fruit juices and processed vegetables have plenty of space for the application of these health adjuncts. Different spices like ginger, clove, mint, garlic and cinnamon have been used for the remedies of different diseases in India (Kordali et al., 2005). Moreover current researchers focus on its mechanism of action, toxicological effects and sensory attributes, but still plenty to come (Burt, 2004; Davidson, 2006; Gaysinsky and Weiss, 2007). The range of minimum inhibitory concentration of the extracts of herbs and spices lies between 0.2-10μ ml\(^{-1}\). These essential extracts are handful against different pathogens like *Staphylococcus aureus* L. *monocytogenes*, *Shigella dysenteriae*, *Salmonella typhimurium*, *Escherichia coli* and *Bacillus subtilis* (Burt, 2004; Brandi et al., 2006). Generally, because of the lipopolysaccharide outer membrane of Gram-negative bacteria are less sensitive to the antimicrobial agents, that restricts diffusion of the hydrophobic compounds. However, it does not mean that Gram-positive bacteria are always more vulnerable (Burt, 2004). Gram-negative bacteria are typically more unwilling to the plant-origin antimicrobial compounds and still it shows no effect as compared to Gram-positive bacteria (Stefanello et al., 2008).

Some phytochemicals with stronger anti-microbial activity be effective at MIC 1000 ppm. It can vary depending upon different conditions (Ceylan and Fung, 2004). The proposed antimicrobial effect highlights that microbial cells are prone to the extracts. They also attack the cell membrane made up of phospholipids bilayer and denature the enzymes. The degradation of fatty acids results in the breakdown of unsaturated fatty acids. In contrast with the natural antimicrobials, the chemical antimicrobials are not safe because they are carcinogenic in nature. The point of concern for the use of chemical preservatives is the toxicity and safety of these chemicals. At the present time, consumers are more concerned with the safety requirement of these chemicals (Skandamis et al., 2001). Natural antimicrobial are good replacers as they suppress the growth of different microbes. It is also helpful to reduce the processing and preservation costs, preventing the contamination and reducing the necessity for antibiotics. While, health issues could be solve by strengthening immune system (Abotaleb and Kawai, 2008; Fisher and Phillips, 2008).

**SPICES**

In food products spices are mostly used as natural antimicrobial agents. For thousands of years, it has been used for preserving the foods and as food additives to improve flavor and aroma. The antimicrobial activities of most of the spices and their active components have been studied. Investigations confirm that onion, garlic, cloves, cinnamon, black paper, ginger, and other spices reduce the growth of food borne pathogens, yeast, molds or spoilage bacteria. Different spices exhibits different antimicrobial and antibacterial property against different strains within the same species. Different spices have different antimicrobial/antimicrobial activity depending on the type of spices, nature of the spices (such as dried, fresh, or extracted forms) and also depend upon the harvesting seasons and geological sources. Hence, it is proved that spices essential oils are more powerfully antimicrobial than it is accounted as an additive (Gaysinsky and Weiss, 2007).

**CLOVE**

Clove belongs to Eugenia caryophyllata that is a tree (*Syzygium aromaticum*) and it is aromatic dried buds in nature. It is worn as a spice in almost all the world’s fare. The word “Clove” is derived from the French word ‘Clou’ and the English word ‘Clou’, both have same meaning ‘nail’- from the likeliness of the flower bud of the Clove tree to a broad-headed nail (Li et al., 2005). Cloves are inhabitant to the Moluccas, previously known as the Spice Islands of Indonesia. They have been consumed in Asia for more than 2,000 years. The countries, in which it is mostly cultivated, are Sri Lanka, Indonesia, China and Madagascar (Bureau of Drug Administration of China, 1989). Bud Oil of the Clove has certain properties include insecticidal, antioxidant, antibacterial and antifungal agent. By custom it has been used in the food as a flavoring agent and preservative as antimicrobial substance (Velluti et al., 2003). The production of clove has averaged approximately 80,000 ton/year, in recent years. Indonesia is the world’s largest producer at 50,000-60,000 ton/year. USA, Saudi Arabia, France and
India are the main importing countries of clove. Clove has vital role as a spice in trading and has high value for their therapeutic activity. Clove is a rich source of manganese, vitamin K, vitamin C, dietary fiber, omega 3 fatty acids and an excellent source of calcium and magnesium. Iron, proteins, carbohydrates, phosphorus, sodium, potassium, and hydrochloric acid is also present in clove (Kim et al., 1998). The most important compounds of clove is phenylpropene eugenol and it is well known aromatic compound. Eugenol comprises 70-90% and remaining 15% dry weight (Shobana and Naidu, 2000). Microorganisms such as Aspergillus sp., Alternaria sp., Lactobacillus sp., Canninghamella sp., Fusarium sp., Mucor sp., Clostridium sp., Salmonella sp., Bacillus sp. and Penicillium sp. can easily controlled by using clove essential oil (Soliman and Badeea, 2002). Since ancient times clove has been used as medicine. Eugenol is the main necessary component of clove oil that has significantly higher antimicrobial properties against food micro-organisms. By the application of clove essential oil molds, yeasts and bacterial growth could be controlled (Burt, 2004). Eugenol is the main bioactive component of clove, which make it effective against various health ailments e.g. digestive tract cancers and joint inflammation (Friedman et al., 2002). The cloves are anti-ulcerogenic, anti-inflammatory, anti-mutagenic, anti-oxidant, antiparasitic and antithrombotic. Dried flower buds of cloves used for acne, warts, parasites and scars (Miyazawa and Hisama, 2003).

GARLIC

Garlic belongs to Alliaceae family and its botanical name is Allium sativum. It has hot, pungent flavor that mellows and sweetens with cooking. It has been used for culinary as well as for medicinal purpose. Garlic is used as medicine for many years. It has been also claimed that garlic prevent from cardiovascular diseases, high blood pressure and high cholesterol. It also protects against various cancer as well as improves immune system response. For six month daily dose of garlic in the form of extract 1ml/kg body weight can reduce the oxidative stress in the patient’s blood (Karuppiah and Rajaram, 2012).

Garlic has antimicrobial activity and without showing cytotoxic effect on normal cells it has ability to induced apoptosis. It has great antimicrobial potential against gram positive bacteria, gram negative bacteria and food borne pathogens including Salmonella, Streptococcus, Staphylococcus, Coliform, Lactobacillus and some anaerobic bacteria (Purwanti et al., 2014).

Allicin is considerable bioactive compound present in garlic which shows stong antimicrobial activity and scavenging antioxidant compound (Chung, 2006). The allinase enzyme accountable for thiosulfanate conversion and becomes inactivated below 3.5 pH or with heat. Microwave radiation will damage allinase enzyme activity within one minute. (Pedrazza-Cheverri et al., 2006).

Garlic indicates anti-inflammatory activity and immunomodulatory effect. It can be used in treatment of arterial hypertension due to its hypolipemic and antioxidant properties (Kyo et al., 2001). Among others, garlic possesses anti-atherosclerotic and anti-thrombotic activity (Duda et al., 2008). Bioactive compounds derived from garlic demonstrate anticancer activities (Lai et al., 2012) and they are potential to decrease the risk of cancer metastasis inhibiting tumor cell motility (Park et al., 2011).

GINGER

The scientific name of ginger is Zingiber officinale. It belongs to small family, that has 800 species and 45 genera, Zingiberaceae. Ginger has active component that known as curcumin (Milner, 2006). It interferes in the formation of cell membrane of some pathogens like Salmonella and E. coli (Amagase, 2006). It is a plant growing in 1-3 feet in height. A club like spike of yellowish purple flower in cultivation (Tyler, 2002). Ginger is truly domestic remedy of various infections. Fresh ginger is used for cold diseases such as asthma, nausea, colic, cough, dyspepsia, swelling, and heart palpitation. A paste of powder dried ginger was used to relief headache when it is mixed with honey. It also use to alley nausea (Karuppiah and Rajaram, 2012). Mixture of honey and ginger show high antimicrobial activity against the Gram positive bacteria and Gram negative bacteria (Patel et al., 2011).

CINNAMON

Cinnamon belongs to genus Cinnamomum and family Lauraceae. For thousands of year it is used for culinary as well as for medicinal perspective (Ranasinghe et al., 2012). The production rate of this spice is 27500-35000 tons/year (Madan et al., 2004). The important component identified is C. Zeylanicum. This component consists of two chemical volatile phenols and poly phenols. Cinnamon normally refers to the bark of C. Zeylanicum and C. Aromaticum that is used for the preparation of many beverages, chocolate, liquors and spicy candies. One of the most important properties of cinnamon is that it shows as antibacterial agent against the Gram positive bacteria.
and Gram negative bacteria (Krishnamoorthy et al., 2004). Major antibacterial component in cinnamon is cinnamaldehyde. Cinnamaldehyde reported to restrain the growth of *E. coli, S. aureus and Salmonella Typhimurium* (Hoque et al., 2008). Furthermore, it also possesses strong antifungal, antibacterial, larvicidal, antitermitic, insecticidal and nematicidal properties (Kim et al., 2006).

**HERBS**

The quality and quantity of food is mainly reduced by the presence of food borne and spoilage microorganisms. The disease causing microbes including fungi, bacteria, yeasts and molds produce mycotoxins, alfatoxins and various carcinogenic substances. Certain chemical additives and preservatives are being extensively used for preserving food. But these chemicals render the food toxic and carcinogenic. Increased concern of consumers regarding safe and healthy food creates an urge to use natural products for food preservation. Nature has provided plant essential oils with numerous antimicrobial and antibacterial properties. Natural herbs and spices contains antimicrobial effects which can be used for the preservation of food (Omidbeygi et al., 2007).

The strongest antimicrobial properties are processed by the essential oils of thyme, oregano, mint, clove and cinnamon. These essential oils are highly effective in curing human diseases, wounds and infections. Essential oils from herbs acquire strong antibiotic activity and act as powerful tool against bacteria which are drug resistant. Essential oils that contains high amount of phenolic compounds are characterized to be the best antibacterial (Sienkiewicz et al., 2012).

**THYME**

An evergreen herb, thyme commonly used in medicines, culinary and as ornamental plant. *Thymus citriodorus, Thymus herba-barona, Thymus pseudolanuginosus, Thymus serpyllum, Thymus praecox and Thymus vulgaris* are the important species and cultivars of Thymus plant. Essential oil of Thyme along with oregano is being used as preservatives in meat products and found to be very useful in controlling food spoilage microorganisms. These aromatic oils enhance flavor and act as antimicrobials. The seven main components of thymus essential oils are a-pinene, p-cymene, g-terpinene, linalool, a-terpineol, thymol and carvacrol. The major mechanism of antimicrobial components thymol and carvacol is to deteriorate the outermost membrane of gram negative bacteria. This releases liposaccharides and ATP becomes permeable to the cytoplasmic membrane. This mechanism works best against *Escherichia coli* and *Salmonella* spp. (Boskovic et al., 2015). It has been reported that thymol is effective to destroy coliforms, when used at the concentration of 250, 500 and 750 mg/kg of beef minced patties and stored for 16 days under ordinary or modified packaging at refrigeration temperature. According to another research, it has been found that by covering the surface of meat products by 0.8% thymol, 2-3 log units had been decreased (Emiroglu et al., 2010).

**OREGANO**

Oregano (*Origanum vulgare*), a perennial herb, sometimes called wild marjoram belongs to mint family. The basic components which contribute properties to the herb are carvacrol, thymol, limonene, pinene, ocimene, and caryophyllene. Monoterpenoids and monoterpenes are the chemical components of essential oil of oregano which contributes sensory and chemical attributes to the products. Oregano along with marjoram essential oil is effective to control gram positive and negative bacteria (Goni et al., 2009). Oregano is a strong weapon against the two food spoilage molds *Aspergillus niger* and *Aspergillus flavus*. Oregano has the highest potential compared with other essential oils to restrict mycelium growth by 57% when used at 2mL concentration/ 18mL culture medium concentration. Many possible mode of action of these antimicrobial have been reported. It has been studied that these antimicrobials contains phenolic compounds which at low concentrations effects enzyme activity, denatures protein and loss of cell permeability (Viuda-Martos et al., 2007) Silva and Junior (2010) analyzed essential oils from oregano for its antibacterial activity against multi resistant bacteria including *E. coli, P. aeruginosa, E. faecalis, K. pneumonia* and *Acinetobacter baumannii*. The growth of all the bacterial strains was inhibited at the concentrations of 0.125% except *P. aeruginosa* was inhibited at the concentration of 0.5%. Antibacterial property of oregano EO in meat products was investigated and found that bacteria which are gram positive are more vulnerable to them.

**ROSEMARY**

Rosemary (*Rosmarinus officinalis*), an evergreen, aromatic, perennial herb, belongs to genus *Rosmarinus*. It has needle like leaves and is grown as decorative plant in gardens. Rosemary leaves either fresh or dried are used in culinary to give aroma to roast and barbequed meat particularly. Rosemary EO is being used in pharmaceutical applications, as taste enhancer, antioxidant, antimicrobial and food...
preservative. Rosemary contains antibacterial and antifungal agents against bacteria and fungi. Rosemary contains carnosic acid and carnosol as antioxidants which are mainly responsible for high antimicrobial activity. Rosemary leaves extract contains phenolic compounds which are found to be devastating against *Leuconostoc mesenteroides, Lactobacillus delbrueckii, Saccharomyces cerevisae* and *Candida krusei* (Tavassoli and Djomeh, 2011). These polyphenols increases functionality and healthiness of food. Antimicrobial activity of rosemary hydro alcoholic extract was proven against *S. mitis, S. sanguinis, S. mutans, S. sobrinus* and *L. casei* standard strains. Use of rosemary extracts for food preservation not only enhances shelf life but also prevents its economic loss (Silva and Junior, 2010).

**LEMON GRASS**

Lemon grass (*Cympopogon citratus* L.) is a perennial herb belongs to poacea family. Fever grass, citronella grass, silky heads and barbed wire grass are the other names of lemon grass. Lemon grass is grown for culinary and medicinal purpose in Asia and India. Lemon grass oil has antifungal properties and is used as a preservative, pesticide, insect repellant and in soaps. It is also used for the treatment of stomach disorders, malaria and typhoid. Lemon grass oil (LGO), due to its medicinal importance, is used to cure pimples, scabies, headache and circulatory disorder. LGO is used as drug for microbial infections and heals skin related problems. It contains geraniol and citronellol chemical constituents which are active ingredients for household disinfectants and sanitizers. α-citral (geranial) and β-citral (neral) present in oil from lemon grass is responsible for antibacterial activity of microencapsulation of bacteria (gram +ve and gram – ve).

The minimum bactericidal Concentration (MBC) of lemon grass (ethanolic extract) is 128 mg/ml and found to have good bacteriocidial effect on *E. coli, S. paratyphi, S. flexnerii, K. pneumoniae, P. aeruginosa* and *B. subtilis* (Fagbemi et al., 2009). Lemon grass oil has strong fungicidal power that inhibits the growth levels of 35, 45 and 47 species of fungus when used at the concentration of 500, 1000, and 1500 ppm. Lemon grass oil is non-phytotoxic and does not affect plant germination and growth. It contains phytochemicals which shows antimicrobial and preservative properties. Lemon grass oil used at 25 ppm inhibits the production of fungal spores up to 70% (Tzortzakis and Economakis, 2007). Studies have shown that LGO is effective antibacterial and antifungal oil at 1 mg/mL concentration. Strains of *Aspergillus spp., Candida spp., Lactobacillus acidophilus, Morganella morganii* and *Penicillium spp.* were tested and found to be sensitive to lemon grass oil (Singh et al., 2011). The antimicrobial activity of lemon grass oil is studied against pathogenic bacteria including *Escherichia coli, Bacillus cereus, Klebsiella pneumonia, Bacillus subtilis* and *Pseudomonas aeruginosa*. It was found that bacteria which are gram positive are more sensitive to LGO as compared to gram negative. In this study activity of lemon grass oil increases with the increase in its concentration and showed highest at 30% Maximum Inhibitory Concentration (MIC) (Naik et al., 2010). Tyagi and Malik (2010) investigated that lemon grass oil (LGO) when used at 288g/ml and 32.7g/ml concentration inhibits the growth of *Candida albicans*.

**BASIL**

Basil (*Ocimum basilicum*) belongs to Lamiaceae family, is a hard annual plant basically native to India. Basil is used in culinary as fresh or dried herb. It retains its flavor when kept refrigerated or frozen. Thai basil, lemon basil, Sweet basil and holy basil are some of the varieties that are being consumed in Italian food. Oil from basil is characterized by antifungal and insect repellent properties. The chemical components of basil include Citronellol, linalool, myrcene, pinene, terpineol, fenchyl acetate, trans-ocimene, methyl chavicol, eugenol, methyl eugenol and neral. A comparative study has revealed that basil oil plays an antimicrobial role against *Propionibacterium acnes*. This study includes famous culinary herbs, *Ocimum sanctum L.* (holy basil), *Ocimum americanum L.* (hoary basil) and *Ocimum basilicum L.* (sweet basil). Highest growth inhibition of *Propionibacterium acnes* was shown by sweet basil oil at 2.0% v/v conc. and lowest by Holy basil oil at 3.0% v/v conc. (Viyoch et al., 2006). It was investigated that Gram positive bacteria are more susceptible to basil essential oil than to Gram negative bacteria. The chemical composition and the antimicrobial property of Basil are varied by the seasonal variations. A study investigated the antimicrobial property of oil extracted from basil (collected seasonally) against nine pathogens. It was found that samples collected in winter and autumn season shows high antimicrobial activity compared to spring and summer season (Hussain et al., 2008).

**CONCLUSION**

Consumers have turned out to be more conscious about the prepared food they eat. Synthetic additives, which have been utilized as a flavoring agent for a considerable period of time, may prompt negative
...wellbeing results. Additionally, the utilization of food additive have certain disadvantages, for example, expanding cost, taking care of dangers, health hazards and environmental pollution. In this way, the trend is shifting towards supplant natural additives which are low cost, non-hazardous and non-toxic. So in this regard utilization of plant products such as essential oils have been perceived importance since old times. Normal plant items have been utilized for remedial purposes for most of the infectious and non infectious diseases and their utilization is a more noteworthy request now-a-days. Plant essential oils are used as an antiseptic agent since ancient times. As the plant extracts and essential oil are natural products so used for therapeutic purpose. A great number of people rely on plant products because these essential oils are easy to use, cost effective and having no side effects. Plant extract and essential oils are used by most of the population for the administration of different infection diseases, but there is not enough knowledge about how it reacts, safety, toxicity, health hazards and dose. Therefore, it is need of the day to search new, natural, safe, non-toxic and cost effective antimicrobial agents.

REFERENCES


