Microbiology Research Journal International

23(6): 1-8, 2018; Article no.MRJI.41345
ISSN: 2456-7043
(Past name: British Microbiology Research Journal, Past ISSN: 2231-0886, NLM ID: 101608140)

Antibacterial and Antifungal Effect of Cinnamon

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/MRJI/2018/41345
Editor(s):
(1) Laleh Naraghi, Plant Disease Research Department, Iranian Research Institute of Plant Protection, Tehran, Iran.
Reviewers:
(1) Renshan Sun, Third Military medical University, China.
(2) Daisy Machado, UNICAMP, Brazil.
Complete Peer review History: http://www.sciencedomain.org/review-history/24554

Mini-review Article

Received 13th February 2018
Accepted 27th April 2018
Published 10th May 2018

ABSTRACT

Cinnamon (*Cinnamomum zeylanicum*, *and Cinnamon cassia*), the eternal tree of tropical medicine, belongs to the Lauraceae family. Cinnamon is one of the most important spices used daily by people all over the world. Cinnamon primarily contains vital oils and other derivatives, such as cinnamaldehyde, cinnamic acid, and cinnamate. Traditional uses of Cinnamon throughout Asia, Africa, and Europe have been recorded, where it has been used as a medicine. Many researches were done to study the effect of cinnamon as antifungal and antibacterial cause skin, oral infection and foodborne bacteria. The antibacterial activity was certified to the presence of some phytochemicals in the extracts and recommended that it was possibly due to their major component cinnamaldehyde.

Keywords: Antibacterial; antifungal; cinnamon.

1. INTRODUCTION

Spices are one of the most commonly used natural antimicrobial agents in foods and have been used traditionally for thousands of years by many cultures for preserving foods and as food, additives to enhance aroma and flavour [1]. As concern over the safety of chemical additives has risen in recent years, consumer interest in the use of natural products as alternative food

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preservatives has increased [2]. Consequently, natural antimicrobials are receiving a good deal of attention for a number of microorganism control issues. Due to the increasing demand for natural food additives, herbs and spices have emerged as popular ingredients to replace synthetic antimicrobial and antioxidant agents [3,4].

The bark of various cinnamon species is one of the most important and popular spices used worldwide not only for cooking but also in traditional and modern medicines. Overall, approximately 250 species have been identified among the cinnamon genus, with trees being scattered all over the world [5,6]. *Cinnamomum zeylanicum* is one of the oldest herbal medicines, mentioned in Chinese texts as far back as 4,000 years ago, and it is also one of the most frequently consumed spices [7-9].

Food borne illness can cause symptoms that ranged from an upset stomach to more serious symptoms such as diarrhea, fever, vomiting, abdominal cramps and dehydration despending on the etiological agents. Food borne illnesses not only affects the health of individuals, but it can also have a dramatic economic impact. The economic losses from various factors, such as medical treatment, lost wages and productivity, loss of business, recall and destruction of products, and investigation of the outbreaks can be very high [10].

2. METHODOLOGY

The current review was conducted using a complete and organized search of the available literature on the medicinal plant cinnamon. The searches were performed using various databases, including PubMed (http://www.ncbi.nlm.nih.gov/pubmed), Science Direct (http://www.sciencedirect.com/), Scopus (http://www.scopus.com/), Scirus (http://www.scirus.com/), and Google Scholar (http://www.scholar.google.com/).

2.1 Traditional Uses

In addition to being used as a spice and flavoring agent, cinnamon is also added to flavor chewing gums due to its mouth refreshing effects and ability to remove bad breath [11]. Cinnamon can also improve the health of the colon, thereby reducing the risk of colon cancer [12].

Cinnamon is a coagulant and prevents bleeding [13]. Cinnamon also increases the blood circulation in the uterus and advances tissue regeneration [14]. This plant plays a vital role as a spice, but its essential oils and other constituents also have important activities, including antimicrobial [15-18], antifungal [19], antioxidant [20-24], and antidiabetic [25-31].

Cinnamon has been used as anti-inflammatory [32-34], antitermitic [34], nematicidal [35-36], mosquito larvicidal [37], insecticidal [38], antimycotic, [38-41] and anticancer agent [42-45]. Cinnamon has also been traditionally used as tooth powder and to treat toothaches, dental problems, oral microbiota, and bad breath [46,47].

2.2 Chemical Constituents

Cinnamon consists of a variety of resinous compounds, including cinnamaldehyde, cinnamate, cinnamic acid, and numerous essential oils [48] (Table 1). [49] studied the qualitative and quantitative composition of cinnamon (bark) essential oil (Table 2). Singh et al. [50] reported that the spicy taste and fragrance are due to the presence of cinnamaldehyde and occur during the absorption of oxygen. As cinnamon ages, it darkens in color, improving the resinous compounds [50].

2.3 Phytochemical Analysis of Cinnamon

Many studies showed that *C. verum* is an effective antioxidant and antibacterial spice. They attributed these activities of this plant to its phytochemicals as shown in Table 3 reported by [51].

2.4 Antibacterial Effect of *Cinnamomum zeylanicum*

Cinnamon and cinnamon oil have been used against the bacteria that causes skin infection and food borne diseases.

2.5 Effect of Cinnamon Extract and Cinnamon Oil for Bacteria Cause Skin Infection

Several studies on Cinnamon and its components have indicated the effect of it against bacteria cause skin infection [52,53]. *Staphylococcus aureus Staphylococcus epidermidis* [54,55] *Streptococcus pyogenes* [56].

2.6 Effect of Cinnamon Extract and Cinnamon Oil for Foodborne Bacteria

Cinnamon is one of the most spices commonly used as natural antimicrobial agents in foods and have been used traditionally for thousands of years by many cultures for preserving foods and as food additives to enhance aroma and flavor [1] The most common bacteria causing food borne illness are *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* spp., *Listeria monocytogenes*, *Clostridium botulinus*, *Vibrio parahaemolyticus* and others [57]. The antimicrobial properties of cinnamon have been documented [58] *Salmonella*, [59-64] *E. coli*, [65] reported Salmonella *typhi* [66] studied *Bacillus cereus*.

2.7 Antibacterial Effect of Cinnamon for Oral Pathogens

The effect of cinnamon oil to oral bacterial pathogens *Streptococcus mutans*, *S. mitis*, *S. salivarius*, *Aggregatibacter actinomycetemcomitans*, *Porphyromonas gingivalis* and *Fusobacterium nucleatum* was reported by [67]. While the effect of cinnamon extract to *Streptococcus mutans* and *Streptococcus sanguinis* was discussed by [68].

2.8 Mechanism of Cinnamon Oil against Bacteria

[69] documented that An important characteristic of plant extracts and their components is their hydrophobicity, which enables them to partition the lipids of the bacterial cell membrane and mitochondria and rendering them more permeable. Extensive leakage from bacterial cells or the exit of critical molecules and ions will lead to death. [70] certified the antibacterial activity to the presence of some phytochemicals in the extracts and recommended that it was possibly due to their major component cinnamaldehyde.

2.9 Antifungal Effect of Cinnamon and Cinnamon Oil

[71-75] studied the effect of cinnamon for *Candida albicans* [76] evaluated the inhibitory effects of cinnamonon the growth of mycelial of various spoilage pathogens *Aspergillus. niger* [77,78] *Fusarium sambucinum Pythium sulcatum* and *Rhizopus stolonifera*. [77] reported the effect against *Aspergillus flavus*, *Penicillium chrysogenum*, *Penicillium notatum* and *Rhizopus oryzae*. [73] *Cryptococcus* species, [78] studied the effect of cinnamon against fungi isolated from of grape *Alternaria alternata*, *Colletotrichum gloeosporioides*, *Lasiodiplodia theobromae*, *Phomopsis viticola* and *Rhizopus stolonifera*, [79] *Aspergillus fumigatus* [80] *Phaeomoniella chlamydospora*, [81] *Penicillium italicum*, [82] *Mucor* species, [83] *Microsporum gypseum*, *Trichophyton rubrum and T. Mentagraphytes.*

2.10 Mechanism of Cinnamon Oil against Fungi

[84] Investigated the mechanism of how cinnamon oil affect the cell morphology, cell membrane and the activities of the key enzymes in scanning electron microscope (SEM)

Table 1. Chemical constituents of different parts of cinnamon (Vangalapati et al. 2012) [6]

Part of the plant	Compound
Leaves	Cinnamaldehyde: 1.00 to 5.00% Eugenol: 70.00 to 95.00%
Bark	Cinnamaldehyde: 65.00 to 80.00% Eugenol: 5.00 to 10.00%
Bark root	Camphor: 60.00%
Fruit	*trans*-Cinnamyl acetate (42.00 to 54.00%) and caryophyllene (9.00 to 14.00%)
C. zeylanicum buds	Terpene hydrocarbons: 78.00% *alpha*-Bergamotene: 27.38% *alpha*-Copaene: 23.05% Oxygenated terpenoids: 9.00%
C. zeylanicum flowers	(E)-Cinnamyl acetate: 41.98% *trans-alpha*-Bergamotene: 7.97% Caryophyllene oxide: 7.20%

observations revealed that the mycelia morphology alterations of fungi were the markedly shriveled and collapsed hypha, even flatted empty hyphae, swelled cell wall, disrupted plasma membrane, with cytoplasmic matrix leakage. Furthermore, cinnamon oil inhibited the biosynthesis of ergosterol significantly damaging the cell membrane structure, causing the leakage of intracellular ions, protein and the higher absorbance at 260nm. Moreover, cinnamon oil affected the energy metabolism of fungi by decreasing the activities of succinate dehydrogenase (SDH) and malate dehydrogenase (MDH) in tricarboxylic acid (TCA) cycle.

Table 2. Qualitative and quantitative composition of cinnamon (bark) essential oil (Abd El-Baky et al. 2013) [49]

Component	%
α-Thafone	0.37
α-pinene	1.12
Benzaldehyde	0.25
Heptanol	0.79
Sabinene	0.52
1-octen-3-ol	0.68
β-pinene	0.77
Myrcene	0.39
p-cymene	0.66
Limonene	1.48
β-phellandrene	0.37
1,8-cineole	1.01
γ-terpinene	0.99
Octanol	0.33
Linalool	0.54
terpinen-4-ol	0.38
α-terpineol	0.51
trans-carveol	0.51
Nerol	1.06
Neral	1.16
Geraniol	0.78
Geranial	1.79
neryl acetate	0.89
Trans- Cinnamaldehyde	45.13
Cinnamyl alcohol	5.13
Eugenol	7.47
Dihyroeugenol	3.31
Ethylcis-cinnamate	3.68
t-Methyl cinnamate	2.19
Methyl eugenol	5.23
Isoeugenol	1.59
Cis-Caryophyllene	Tr
t-Cinnamic acid	0.41
Cinnamyl actate	0.21
α-Caryphyllene	Tr
E-ethyl cinnamate	0.73

Table 3. Photochemical analysis of cinnamon

Component	*Cinnamomum verum*
Carbohydrates	+
Proteins	+
Glycosides	+
Steroids	++
Alkaloids	++
Flavanoids	++
Saponins	+
Anthraquinones	++
Tannins	++
Terpenoids	+
Anthocyanins	-
Leucoanthocyanins	-
Coumarins	+
Emodins	-

+ Shows the presence of phytochemicals, ++ shows the presence of abundant phytochemicals, - shows the absence of phytochemicals

3. CONCLUSION

In conclusion, *Cinnamomum zeylanicum* can be used as antifungal and antibacterial treatment for bacteria that causes skin, oral infections as well as foodborne bacteria. The antibacterial activity was certified to the presence of their major component cinnamaldehyde in the extract.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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