

Available online at [GSC Online Press Directory](https://www.gsconlinepress.com/)

GSC Biological and Pharmaceutical Sciences

e-ISSN: 2581-3250, CODEN (USA): GBPSC2

Journal homepage: <https://www.gsconlinepress.com/journals/gscbps>

(REVIEW ARTICLE)



Cinnamon bark as antibacterial agent: A mini-review

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Publication history: Received on 14 January 2020; revised on 20 January 2020; accepted on 23 January 2020

Article DOI: <https://doi.org/10.30574/gscbps.2020.10.1.0012>

Abstract

The rise in cases of antibiotic-resistant pathogens has become a global phenomenon threatens human health and requires the search for alternatives to fallen antibiotics. Medicinal plants have a huge phytochemical diversity that qualifies them as a competitive alternative. Cinnamon bark is a tropical popular spice that comes from *Cinnamomum* spp. Which are rich in bioactive phytochemical molecules. It has multiple traditional medical uses and considered one of those antibacterial plants that were extensively studied. This mini-review displays the antibacterial potential of cinnamon bark as a promising source for new antibacterial agents, which could be used in pharmaceutical formulations to combat the multi-drug resistant bacteria.

Keywords: *Cinnamomum*; Cinnamon bark; Antibacterial; Bacterial pathogens; Spices

1. Introduction

No doubt that the discovery of antibiotics in the twentieth century is considered one of the most important drug discoveries in that century, antibiotics were powerful weapons that helped mankind in his eternal battle against microbial pathogens and led to control numerous infections. Very shortly, some community-acquired infections including *Staphylococcus aureus*, *Enterococcus faecium*, *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, *Klebsiella pneumoniae* and some *Enterobacter* species had developed remarkable resistance against the discovered antibiotics and therefore scientists had to innovate more antibacterial drugs [1]. Unfortunately, the prevalence phenomenon of multi-drug resistant (MDR) bacteria are steadily increasing and on the other side the strenuous efforts to develop new antibiotics is speedily decreasing as reported by Food and Drug Administration (FDA) which announced that we are going to a real health crisis whereas the approval for new antibiotics had declined by 56% over the past three decades [2].

On the other side, interest in medicinal plants are flourished and numerous investigations on the antibacterial potential of plant-based products showed remarkable efficacy against different bacterial pathogens without serious side effects compared to the antibiotics. Plants produce some bio-active phytochemical metabolites such as alkaloids, flavonoids, flavones, flavonols, terpenoids, tannins, lectins, quinines, coumarins, polypeptides and essential oils that considered as good sources for new antibacterial agents and interact with bacterial cells using varied mechanisms and mode of actions [3]. Actually, unlike the limited, non-renewable capacity of current antibiotics, plants are a continuous renewable living source for bio-active phytochemical molecules of huge biological diversity on Earth (250,000 to 500,000 plant species) [4]. Cinnamon bark is a famous spice used as a food additive and seasoning, in addition to its wide applications in traditional medicine. In scientific term, more than 70 research papers have been published on cinnamon bark and reported numerous health benefits such as anti-oxidant, anti-inflammatory, wound healing properties, lowering of blood pressure, blood glucose, and cholesterol, anti-Alzheimer's disease, anti-gastric ulcers, inhibits osteoclastogenesis,

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anti-parasitic, hepato-protective and anti-microbial [5]. Therefore, the aim of the current paper is to review the research outcomes regarding the possible use of cinnamon bark as an antibacterial drug against different pathogens.

2. Cinnamon in traditional medicine

Cinnamon bark has been utilized since thousands of years as a spice, flavoring agent and food seasoning, it is also used in traditional medicine for treatment of diabetes, tumors, diarrhea, fever, common cold, toothache, nausea, chill, flatulence, amenorrhea, headache, cough, cardiovascular diseases, eye inflammation, bad breath, rheumatism, dyspnea, leukorrhea, frigidity, vaginitis, impotency and neuralgia [6,7,8], and many more (Figure 1). Botanically, cinnamon is a tropical tree, the inner bark is mostly used as a spice, it belongs to family Lauraceae, comprises about 250 species, four of them are of commercial importance and traded worldwide, which are Ceylon cinnamon (*Cinnamomum verum* or *Cinnamomum zeylanicum*) from India and Sri Lanka, Chinese cinnamon (*Cinnamomum cassia* or *Cinnamomum aromaticum*), Indonesian cinnamon (*Cinnamomum burmannii*) and Vietnamese cinnamon (*Cinnamomum loureiroi*) [9].

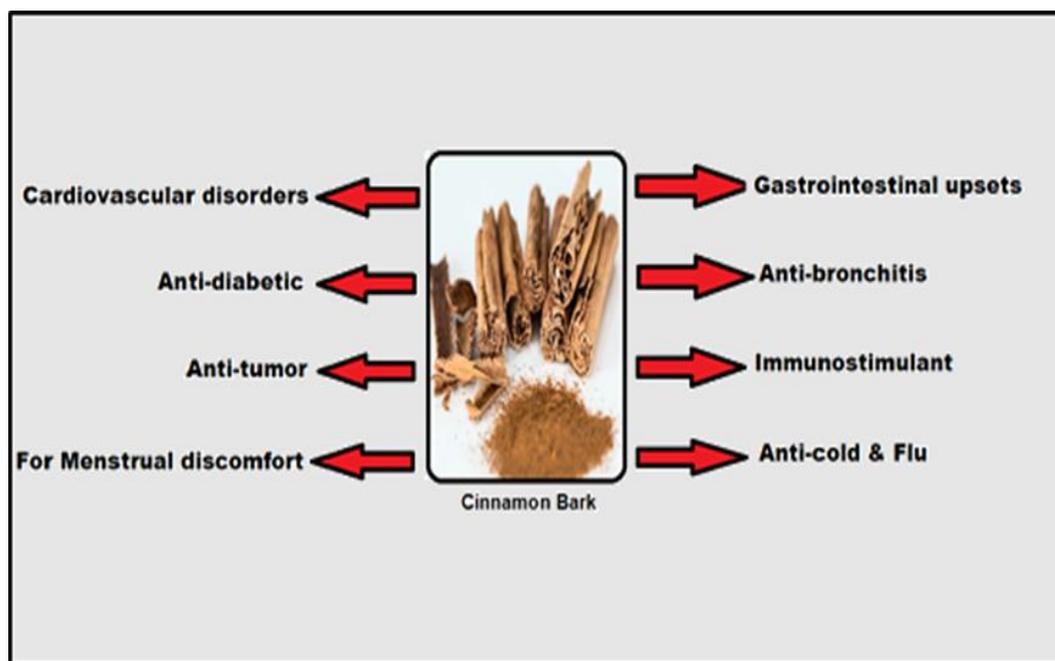


Figure 1 Some applications of cinnamon bark in traditional medicine

3. Phytochemical constituents of Cinnamon

Plenty of biological studies have been conducted to evaluate the bio-active properties of cinnamon bark spice. However, phytochemically, cinnamon has been exploring very little. Different classes of compounds have been documented from cinnamon (Figure 2). O-methoxycinnamaldehyde (**1**) has been previously isolated from powder Cinnamon. Cinnamon is a rich source of vital oils as well as other derivatives including cinnamic acid (**2**), cinnamaldehyde, and cinnamate (**3**). Various chemical constituents such as cinnamaldehyde (**4**), cinnamyl acetate (**5**), α -thujen (**6**), terpineol (**7**), α -cubebene (**8**), eugenol (**9**), and coumarin (**10**) has been documented from cinnamon and some of these compounds have been reported for antimicrobial activity [8, 10, 11]. Cinnamaldehyde is of great importance as the majorities of scientific studies claimed that it has a powerful antibacterial activity [12]. Although, it has been documented that cinnamon also has some side effects when consumed in high quantities. It was reported that *Cinnamomum cassia* has high contents in coumarin and this compound has harmful effects on the liver and coagulation, compared with *Cinnamomum zeylanicum* which has low contents of coumarin [13]. Therefore, the phytochemical contents of cinnamon should be clinically monitored.

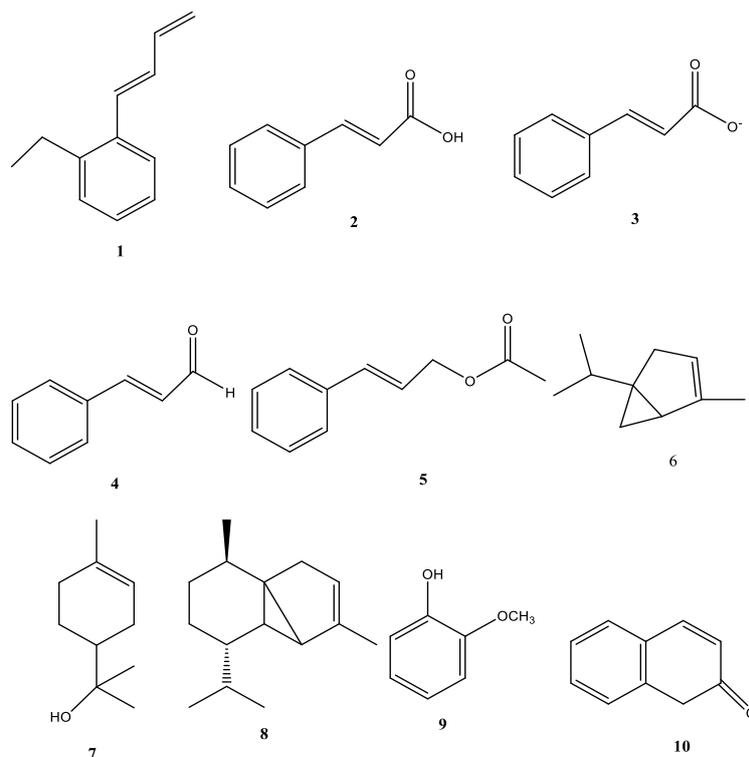


Figure 2 The chemical structures of some important compounds isolated from cinnamon*

*1: O-methoxycinnamaldehyde, 2: Cinnamic acid, 3: Cinnamaldehyde, and cinnamate 4: Cinnamaldehyde, 5: Cinnamyl acetate, 6: α -thujen, 7: Terpineol, 8: α -cubebene, 9: Eugenol, and 10: Coumarin.

4. Cinnamon as an antibacterial agent

The renewed interest in medicinal plants, allowed researchers to investigate the antibacterial potential of some spices of medicinal background dating back to thousands of years, such as cinnamon bark. Several scientific studies reported that cinnamon bark has powerful antibacterial agents (Table 1). It was published that the essential oils of *Cinnamomum cassia* (bark) showed remarkable inhibitory effect against three MDR-pathogens, namely *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*; Moreover, it was observed that there is a considerable synergistic inhibition of that essential oil with streptomycin [14]. *Paenibacillus larvae* is a causative agent for a serious bacterial disease affecting honeybee brood, worldwide; it was stated that Cinnamaldehyde and eugenol extracted from the essential oils of *Cinnamomum verum* proved to have significant antibacterial effects against this bacterium [15] The essential oils and cinnamaldehyde extracted from *Cinnamomum zeylanicum* showed good antibacterial activities against seven Gram-negative and nine Gram-positive fish pathogenic bacteria and recommended as a safe alternative to control bacterial infections in aquaculture [16]. The essential oil of *Cinnamomum verum* bark tested against four food-borne bacterial pathogens (Gram-positives and gram-negatives), it exhibited strong antibacterial activity against all tested bacteria and recommended as a natural preservative in the food industry [17]. Another study was also evaluated the antibacterial potential of crude bark extract of little-investigated Indonesian cinnamon (*Cinnamomum burmannii*) against five food-borne bacteria (*Staphylococcus aureus*, *Bacillus cereus*, *Listeria monocytogenes*, *Salmonella anatum* and *Escherichia coli*) and recorded efficient antibacterial activity [18]. A study on barks of four cinnamon species (*Cinnamomum cassia*, *C. loureiroi*, *C. burmannii* and *C. wilsonii*), all investigated plants showed varied remarkable antibacterial activity against food-borne pathogens (*Staphylococcus aureus*, *Listeria monocytogenes*, *Escherichia coli* O157:H7, and *Salmonella anatum*) [19]. The ethanol extract bark of *Cinnamomum burmannii* was examined against nine bacterial strains isolated from patients attending a Dental Clinic suffering from dental caries, results revealed that the extract is significantly inhibited all *Streptococcus* spp., and accordingly recommended as mouthwash [20]. The essential oil of *Cinnamomum aromaticum* was effective against four enteropathogenic bacterial isolates associated with neonatal calves' diarrhea (*Klebsiella* spp., *Kluyvera* spp., *Escherichia coli* F17, and *Escherichia coli* F5) and recorded remarkable minimum inhibitory concentration as low as 0.625 $\mu\text{L}/\text{mL}$ [21]. *Cinnamomum zeylanicum* exhibited significant activity against some extended-spectrum beta-lactamase-producing bacterial strains, namely *Escherichia coli* and *Pseudomonas aeruginosa* [22]. In trying to understand the mode of action of cinnamon as a powerful antibacterial agent, some studies

reported that the molecules extracted from cinnamon bark possessed membrane permeabilizing activity in conjunction with anti-quorum sensing effects [23].

Table 1 Antibacterial activity of Cinnamon bark (*Cinnamomum* Spp.) as reported in previous studies

Cinnamon species	Extract	Susceptible bacteria		Ref.
		Gram-positive	Gram-negative	
<i>Cinnamomum cassia</i>	Essential oils	<i>Staphylococcus aureus</i>	<i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i>	[14]
<i>Cinnamomum zeylanicum</i> , (Syn. <i>C. verum</i>)	Cinnamaldehyde and eugenol	<i>Paenibacillus larvae</i>	-	[15]
<i>Cinnamomum zeylanicum</i> , (Syn. <i>C. verum</i>)	essential oils and cinnamaldehyde	<i>Lactococcus garvieae</i> (FP5245), <i>Streptococcus iniae</i> (S131, S186, S530 and FP3287), <i>Streptococcus parauberis</i> (S124, S527, S1466 and FP5228).	<i>Edwardsiella tarda</i> (ED47, ED45, and FP5060), <i>Photobacterium damsela</i> (FP4101), <i>Vibrio harveyi</i> (FP 8370), <i>Vibrio ichthyenteri</i> (FP 4004)	[16]
<i>Cinnamomum verum</i> (Syn. <i>C. zeylanicum</i>)	Essential oils	<i>Staphylococcus aureus</i> , <i>Bacillus cereus</i> .	<i>Escherichia coli</i> , <i>Salmonella typhimurium</i>	[17]
<i>Cinnamomum burmannii</i>	Ethanol extract	<i>Streptococcus mitis</i> , <i>Streptococcus sanguinis</i> , <i>Streptococcus salivarius</i> , <i>Streptococcus pluranimalium</i> , <i>Streptococcus pneumoniae</i> , <i>Streptococcus alactolyticus</i> , <i>Kocuria rosea</i> , <i>Kocuria kristinae</i> , and <i>Spingomonas paucimolis</i>	-	[20]
<i>Cinnamomum burmannii</i>	Crude extract	<i>Staphylococcus aureus</i> , <i>Bacillus cereus</i> , <i>Listeria monocytogenes</i> .	<i>Salmonella anatum</i> , <i>Escherichia coli</i>	[18]
<i>Cinnamomum cassia</i> , <i>C. loureiroi</i> , <i>C. burmannii</i> <i>C. wilsonii</i>	N-butane and ethanol extracts	<i>Listeria monocytogenes</i> , <i>Staphylococcus aureus</i>	<i>Escherichia coli</i> O157:H7, <i>Salmonella anatum</i>	[19]
<i>Cinnamomum aromaticum</i> (Syn. <i>C. cassia</i>)	Essential oil	-	<i>Klebsiella</i> spp., <i>Kluyvera</i> spp., <i>Escherichia coli</i> F17, and <i>Escherichia coli</i> F5	[21]
<i>Cinnamomum zeylanicum</i> , (Syn. <i>C. verum</i>)	Essential oil and ethanolic fraction	-	<i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i>	[22]

5. Conclusion

Medicinal plants were the main source of remedies since ancient times. In the modern era, the discovery of antibiotics mostly from microorganisms (fungi and bacteria) and later the development of synthesized antibacterial drugs has led to neglect herbal medicine. The misuse of this miraculous drug has led to a global prevalence of antibiotic-resistant pathogens. In searching for effective alternatives, scientists have revived the interest in plants as a remarkable renewable source of drugs. Although, the isolation of antibacterial molecules in a pure form for the pharmaceutical industry and variations in phytochemical constituents between species and varieties are big challenges. Based on the current review, Cinnamon bark is a powerful wide-spectrum antibacterial agent which attributed to its phytochemical constituents particularly cinnamaldehyde. Although, some of its constituents such as coumarins reported serious adverse effects. Therefore, intensive and in-depth chemical, biological and pharmacological studies are required in order to isolate the antibacterial molecules and evaluate the safety, dosage and possible side effects.

Compliance with ethical standards

Disclosure of conflict of interest

The authors have not declared any conflict of interests.

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How to cite this article

Abdallah EM, Rauf A and Sadeek AM. (2020). Cinnamon bark as antibacterial agent: A mini-review. *GSC Biological and Pharmaceutical Sciences*, 10(1), 103-108.
