



Review Article

Extraction and Evaluation of Antimicrobial Activity of Cinnamon

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ABSTRACT

Cinnamon is the oldest spice and has been used by several cultural practices for centuries. In addition to its culinary uses, cinnamon possesses a rising popularity due to many stated health benefits. Out of the large number of cinnamon species available, Cinnamomum aromaticum (Cassia) and Cinnamomum zeylanicum have been subjected to extensive research. Available in vitro and in vivo evidence indicates that cinnamon may have multiple health benefits, mainly in relation to hypoglycaemic activity. Furthermore, the therapeutic potential of cinnamon is stated also to be brought about by its anti-microbial, anti-fungal, antiviral, antioxidant, anti-tumour, blood pressure-lowering, cholesterol and lipid-lowering and gastro-protective properties. This page presents a summary of the scholarly literature on C. aromaticum and C. zeylanicum. All experiments listed here involve cinnamon bark and its products. While animal models show significant anti-diabetic potential for both cinnamon species, clinical trials have yielded inconsistent outcomes. Before recommending cinnamon as a successful treatment for people, it is important to conduct well-defined and sufficiently powered randomized controlled clinical trials to assess its therapeutic potential.

INTRODUCTION

Plants have long been utilized as a major source of medicine in rural areas of underdeveloped countries, treating a variety of ailments.^[1] Cinnamon is a tropical Asian spice and a native plant from Sri Lanka.^[2] It obtained from the inner bark of several trees from the genus Cinnamomum^[3]. The barks and leaves are used to treat numerous ailments and have antibacterial, antimicrobial, antidiabetic, antioxidant, anti-inflammatory,

insecticidal and anticancer properties^[4 - 14]. Cinnamomum (family Lauraceae) includes around 300 evergreen aromatic plants and shrubs^[15]. Four species have a high economic value due to their numerous culinary applications as popular spices worldwide: Cinnamon zeylanicum Blume (a synonym of Cinnamon verum J. Presl, known as Sri Lanka cinnamon), Cinnamon loureiroi Nees (known as Vietnamese cinnamon), Cinnamon burmanni (Nees & T. Nees) Blume (known as Indonesian cinnamon), and Cinnamon aromaticum

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Nees (a synonym of Cinnamomum cassia (L.). J. Presl (also known as Chinese cinnamon) [16]. Cinnamon is the dried bark of *C. zeylanicum* and *C. aromaticum*, used in chocolate, drinks, spicy candies, and liquors. [17] Cinnamon has been used to promote health and treat ailments like inflammation, gastrointestinal issues, and urinary infections. [18-19]. Furthermore, cinnamon is utilized in a variety of savory foods, pickles, soups, and Persian desserts. Cinnamon bark, leaves, flowers, and fruits are utilized to extract essential oils for cosmetics and food items. Cinnamon has been utilized in traditional Chinese medicine for over 4000 years for neuroprotection and diabetic therapy [20]. In medicine it acts like other volatile oils and once had a reputation as a cure for colds. It was also used to treat diarrhoea and other problems of the digestive system. Cinnamon has significant antioxidant activity. The Cinnamon essential oil contains antibacterial qualities that help preserve some foods. "Cinnamon" has been shown to have exceptional pharmacological properties in the treatment of type II diabetes. Cinnamon has traditionally been used to relieve dental pain and battle bad breath, and its continuous use is considered to stave off common cold and help digestion [21]. Cinnamon herb is used by numerous cultures over the world for several centuries. The tropical evergreen plant. Cinnamon comes in two varieties: *Cinnamomum zeylanicum* (CZ) and *Cinnamomum cassia* (CC) were sourced from Inner bark [22]. In Ayurveda, it treats respiratory, digestive, and gynecological diseases. Volatile oils can be found in several parts of the plant, including the bark, leaves, and roots. The *Cinnamomum* genus contains around 200 species, with 20 found in India. The plant contains the same hydrocarbons in different amounts, including cinnamaldehyde in the bark, eugenol in the leaf, and camphor in the root. Camphor is a commercially valuable chemical produced from the plant's root, as opposed to its leaf and bark. In

Sri Lanka and India, the plant is also known as 'real cinnamon'[23-25]. Cinnamon is an ancient and widely used spice that was first exchanged between Asia and Europe.[4] Besides this, it is widely utilized in the Unani system of medicine. The classical literature of the Unani system of medicine is replete with detailed descriptions of Drchin, which is recognized as a valuable treatment for a number of ailments [26,27].



Fig.1 Cinnamon Bark

Table 01. Vernacular names of *Cinnamomum zeylanicum* (Dalchini)[28]

Hindi	Dalchini
English	Cinnamon
Punjab	Dalchini, Darchin
Telegu	Lavanga Patta
Tamil	Ilayangam
Bengali	Daruchini
Malayalam	Karuvapatta, Ilavarngathely
Oriya	Dalechini, Guda twa
Gujarati	Taja Urdu Darchini
French	Cammelle
Spanish	Canela
Urdu	Darchini

HISTORY

Cinnamon has been used since almost 2800 BC, when it was first known as "Kwai" in Chinese. According to the Bible, it was part of Moses' anointing oil, which was used to make people holy. The Romans used it to treat stomach and respiratory ailments. It was also employed in Roman funerals to prevent the stink of deceased bodies. It was used in Egypt to embalm mummies, as well as for its smell and deliciousness. However, being very costly and highly valued, the quest for cinnamon resulted in a world exploration in the fifteenth century. It was the motivation behind Christopher Columbus' expedition that led to the discovery of the new World and for Vasco da Gama's exploration of South India. Sri Lanka also exists. The native of true cinnamon or Ceylon Cinnamon was then discovered to be in Sri Lanka (also as Ceylon) [29].

CULTIVATION OF CINNAMON

Approximately 27,000-35,000 tons of cinnamon are produced globally each year.[30] It is mostly grown in China, Seychelles, Madagascar, and Sri Lanka, with small-scale cultivation in Vietnam and India. This plant thrives in a variety of weather situations, making it appropriate for cultivation. Cinnamon cultivation requires a temperature between 20-30°C and a rainfall of 1250-2500 mm per year. Cinnamon is commonly propagated through dried seed and vegetative propagation.[31]

CHEMICAL COMPOSITION OF CINNAMON

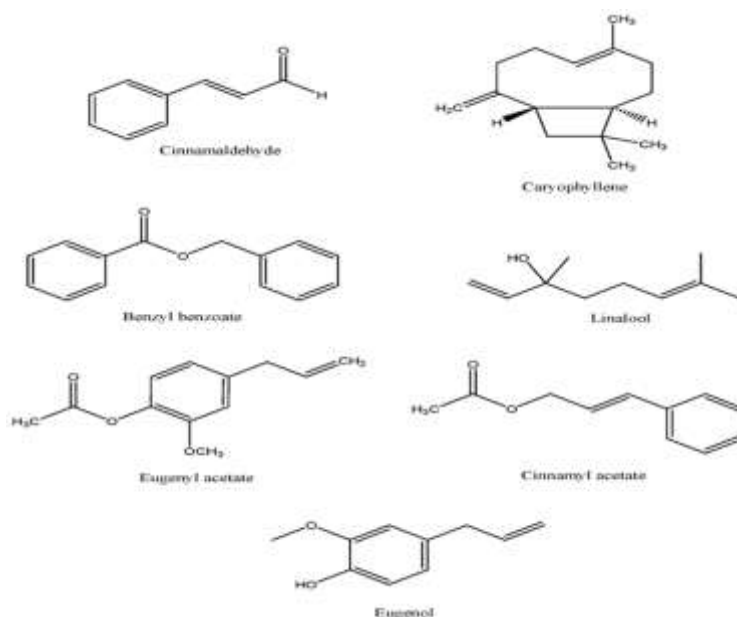
Cinnamon includes many resinous chemicals, including cinnamaldehyde, cinnamate, cinnamic acid, and essential oils. Cinnamon's spicy flavour

and pungent aroma are due to the presence of cinnamaldehyde.[32] Cinnamon contains essential oils such as trans cinnamaldehyde, cinnamyl acetate, eugenol, L-borneol, caryophyllene oxide, b-caryophyllene, L-borneol acetate, nerolidol, alpha-cubebin, alpha-terpineol, terpinolene, and alpha thujene [33-40]. *Cinnamomum zeylanicum* contains a variety of chemical compounds, including aldehydes, alcohols, esters, phenols, acids, monoterpenes, diterpenes, sesquiterpenes, benzopyrones, hydrocarbons, and flavonoids. *C. zeylanicum* bark essential oil contains several aldehydes such as cinnamaldehyde, methoxy cinnamaldehyde, hydro cinnamic, benzaldehyde, vanillin, cumin aldehyde, benzenepropanol, 2-methyl-3-phenyl-propanal, and citronellal. *Cinnamomum zeylanicum* produces alcohols such as α -terpineol, linalool, and bisabolol, as well as esters such as cinnamyl acetate, cinnamaldehyde diethyl acetal, methyl cinnamate, hydro cinnamyl acetate, benylbenzoate and bornylacetate. Various plant parts contain cinnamic acid, ferulic acid, caffeic acid, gallic acid, protocatechuic acid, oleic acid, and p hydroxybenzoic acid. *Cinnamomum zeylanicum* contains several monoterpenes, including p-cymene, limonene, α -terpinene, α pinene, camphene, camphor, 1,4-cineole, β -pinene, α -phellandrene, and 3-carene.[41-42] Cinnamon's chemical composition includes eugenol, limonene, terpineol, catechins, proanthocyanidins, tannins, linalool, safrole, pinene, methyl eugenol, and benzaldehyde[43] To address this constraint, the supercritical fluid extraction method was devised. This method is effective for isolating unstable compounds, both thermally and chemically. Eugenol is the primary component of cinnamon leaves, with methyl, and ethyl cinnamate present in the leaf oil. Cinnamon bark oil contains benzyl benzoate, while root bark oil contains terpinene-4-ol [44-46]



Table.02. The primary chemical constituents and concentration ranges of various varieties of cinnamon essential oils [47]

compound	C. cassia(%)	C. verum(%)	C.zeylanicum(%)	C.burmannii(%)
Cinnamaldehyde.	60-90	60-90	60-90	55-85
Eugenol.	5-15	38.42	5-15	110-20
Cinnamyl acetate	5-10	3-8	5-10	5-12
Linalool.	1-5	2-6	1-5	2-7
β -caryophyllene.	1-3	1-4	1-3	1-5
Benzyl benzoate.	0.5-2	0.5-2	0.5-2	0.5-2
Clovene.	0.5-2	0.5-2	0.5-2	0.5-2
Eugenol acetate.	0.3-1	0.3-1	0.3-1	0.3-1
Coumarin.	0.05-0.5	0.05-0.5	0.05-0.5	0.05-0.5

**Figure-02. The major and minor chemical constituents of cinnamon essential oil [48-50]**

PHARMACOLOGICAL ACTIVITY OF CINNAMON

ANTIMICROBIAL ACTIVITY

Cinnamomum zeylanicum is a well-documented antibacterial agent due to its high hydrophobic properties, as per numerous studies.[51-52] Essential oils from *C. zeylanicum*, *Cuminum cyminum*, *Amomum subulatum*, and *Syzygium aromaticum* have antibacterial activity against *Salmonella typhi*, *Salmonella paratyphoid*, *Escherichia coli*, *Staphylococcus aureus*, *Bacillus*[53] The study found that ethyl acetate was effective against *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*,

while petroleum ether extract was most sensitive to *Bacillus subtilis*.[54]

ANTIBACTERIAL ACTIVITY

Cinnamon extracts, essential oils, and their components have been shown to have antibacterial activities against both Gram-positive and Gram-negative bacteria, which can cause infections and food or cosmetic degradation.

TABLE.02 This list includes cinnamon essential oils and extracts that are effective against both Gram-negative and Gram-positive bacteria.[55]

TYPES OF SAMPLE	BACTERIA
BARK extracts obtained using several organic solvents (ethyl	<i>Staphylococcus aureus</i> (ATCC 25923)

acetate, acetone, and methanol).	Bacillus subtilis (ATCC 6633) Bacillus cereus Streptococcus pyogenes Escherichia coli (ATCC 25922) Klebsiella pneumoniae (ATCC 13883) Pseudomonas aeruginosa (ATCC 27853)
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Cinnamon has significant antibacterial effects, mostly because of its major ingredient, cinnamaldehyde, which effectively fights numerous bacteria (such as *E. coli* and *S. aureus*) and fungi (*Candida*) by destroying cell membranes, dissolving biofilms, and interfering with microbial growth. Guerra et al. (2012) found that combining *C. zeylanicum* essential oil with antibiotics has additive and synergistic antibacterial action.[56]

ANTIOXIDANT ACTIVITY

Hexane, chloroform, and methanol extracts of cinnamon, black pepper, ginger, and turmeric were tested for antioxidant activity using phosphomolybdate and ferric reducing assays. Cinnamon methanol extract exhibits the best antioxidant activity among all extracts.[57] Another study indicated that cinnamon essential oil outperformed lemon oil in terms of antioxidant activity.[58] *C. verum* and *C. aromaticum* polyphenols block 5-lipoxygenase enzyme, reducing oxidative stress in a dose-dependent manner.[59] Antioxidants are chemical compounds that inhibit the oxidation of lipids. Food deterioration is mostly caused by oxidation by free radicals produced by its components, particularly lipids. The food sector extensively uses synthetic antioxidants to prevent food oxidation. Antioxidants protect biological systems from the damaging effects of oxidative stress on carbohydrates, lipids, proteins, and DNA.[60] Cinnamon contains specific antioxidant

phytochemicals such as epicatechin, camphene, eugenol, gamma-terpinene, phenol, salicylic acid, and tannins.[61]

ANTI-INFLAMMATORY ACTIVITY

The methanolic and ethanolic extracts of *C. zeylanicum* inhibited the lipoxygenase (LOX) enzyme activity in mice, resulting in anti-inflammatory action. Collagen-mediated arthritis was artificially produced in the animals. In the model, both extracts were observed to lower the production of pro-inflammatory cytokines [62] Inflammation helps the immune system respond to adverse stimuli such as damaged cells, irritants, and viruses. This process removes the root cause of infection or tissue harm, eliminates apoptotic/necrotic cells and damaged tissue, and initiates tissue restoration. Immune cells (macrophages, neutrophils, and lymphocytes) modulate the inflammatory response to infectious pathogens.[63]

ANTITUMOR ACTIVITIES

Cinnamon has strong anticancer potential by triggering cancer cell death (apoptosis), slowing tumor development, and limiting angiogenesis (new blood vessel production for tumors) via numerous substances such as flavonoids, phenols, and cinnamaldehyde.

Substances' antitumor and anti-cancer properties are linked to their antioxidant and immunomodulatory capabilities. The antioxidant and immunomodulatory characteristics of *C. zeylanicum* and *C. cassia* may indicate anticancer capabilities. Further research is needed to fully understand the anticancer capabilities of cinnamon bark and its primary ingredient, cinnamaldehyde. [64]



- **Targets Cancer Metabolism:** According to this study, it can disrupt cancer cell energy utilization (glycolysis) by lowering glucose absorption and lactate generation.
- **Blocks Angiogenesis:** Cinnamon extracts impede the creation of new blood vessels.
- **Modulates Signalling Pathways:** It interferes with cancer-promoting pathways such as PI3K/Akt/mTOR, which are important in many malignancies (prostate, breast, bladder).

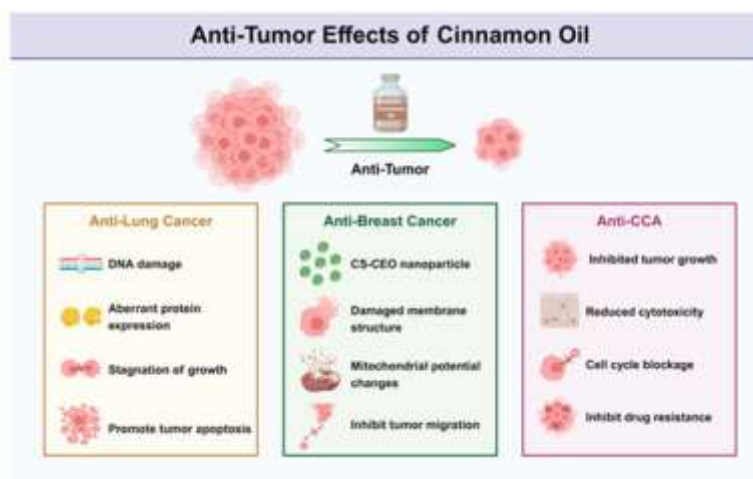


Figure.03[65]

ANTIDIABETIC ACTIVITY

Cinnamomum cassia extract shown anti-diabetic efficacy in type 2 diabetic animal models. Cinnamon extract was given at various dosages for 6 weeks. Blood glucose levels decreased dramatically in a dose-dependent manner as compared to the control.[66]. Cinnamon methanol extract and 50 green teas effectively treated streptozotocin-induced diabetes in 50 rats. The treatment lasted six weeks. The rats had significantly decreased glucose levels after medication. The extracts have shown synergistic effects in treating diabetes. Cinnamon has strong antidiabetic potential, improving blood sugar control by imitating insulin, increasing glucose uptake, reducing carb absorption, and promoting insulin sensitivity via molecules like cinnamaldehyde and MHCPs.

- **Compounds such as MHCPs enhance insulin activity:** allowing cells to use glucose more effectively.
- **Increases Glucose Uptake:** It enhances glucose metabolism and uptake by cells.
- **Improves Insulin Sensitivity:** Activates pathways such as PI3K/AKT and AMPK, lowering insulin resistance.
- **Delays Gastric Emptying:** Reduces postprandial glucose increases by slowing sugar absorption.
- **Reduces Starch Digestion:** Inhibits enzymes that break down starches, reducing glucose release.[67]

GASTROPROTECTIVE ACTIVITY

Cinnamon provides substantial anti-protective properties, primarily through powerful.

antioxidant, anti-inflammatory, and antimicrobial properties that protect against cellular damage, chronic diseases (e.g. heart disease, diabetes), infections, and toxicity. It works by scavenging free radicals, reducing inflammatory markers (TNF- α , IL-6), and inhibiting harmful microbes.

- Protects gastric mucosa.
- used in traditional medicine for indigestion, gas and diarrhea[68]

IMMUNOMODULATORY ACTIVITY

Cinnamon and its principal active constituents, including cinnamaldehyde, have significant anti-inflammatory and immunomodulatory properties. These effects are principally related to the modulation of immune cell signaling pathways and the inhibition of pro-inflammatory mediators.

- Enhance immune response.
- Helps prevent infection and inflammation [69]

ANTI- HIV ACTIVITY

Laboratory studies have revealed that some cinnamon extracts, notably those containing A-type procyanidin polyphenols, exhibit anti-HIV-1 efficacy by inhibiting the virus's entry into host cells and altering immunological responses.

C. zeylanicum can help treat acquired immunodeficiency diseases (AIDS). In this study, 26 herbs were used to treat HIV/AIDS.[70]

ANTI-PARKINSON ACTIVITY

Cinnamomum zeylanicum exhibits antiparkinsonian effects in MPTP-intoxicated mice. Mice received 100 μ l of cinnamon powder soaked in 0.5% methylcellulose (MC). Cinnamon

may help treat Parkinson's disease, according to research findings.[71]

TRADITIONAL USES OF CINNAMON

Polium bark is used in hot beverages to strengthen muscles and alleviate soreness. *C. crassinervium* crushed leaves and bark paste can help with headaches. *C. rhynchophyllum* and *C. soegengii* leaves can help alleviate stomach discomfort and food poisoning.[72] The wood is used to create decorations, furniture, cabinets, and plywood. *C. javanicum* produces robust wood for use in construction and housing. It is used to produce chocolate, drinks, spicy sweets, and liquors, among other products.[73] Cinnamon zest is an enhancing ingredient used in biting gum for its ability to refresh the mouth and eliminate bad breath. Cinnamon can promote colon health, lowering the risk of colon illness.[74]

MEDICINAL USES OF CINNAMON

MICROBIAL ACTIVITY

Essential oils of *C. zeylanicum* and three other herbs (*Cuminum cyminum*, *Amomum subulatum*, and *Syzygium aromaticum*) were tested for antimicrobial activity against *Salmonella typhi*, *Salmonella paratyphoid*, *Escherichia coli*, *Staphylococcus aureus*, *Bacillus licheniformis*, and *Pseudomonas fluorescens*. *C. zeylanicum* had stronger antibacterial action against all bacteria than the other three. significant antibacterial characteristics, primarily due to its primary ingredient, cinnamaldehyde, which effectively fights numerous bacteria (such *E. coli*, *S. aureus*) and fungus (*Candida*) by destroying cell membranes, breaking biofilms, and interfering with microbial growth.[75]

ANTIOXIDANT ACTIVITY

The antioxidant activity of hexane, chloroform, and methanol extracts of cinnamon, black pepper, ginger, and turmeric was assessed using DPPH, phosphomolybdate, and ferric reducing assays. Cinnamon methanol extract exhibits the best antioxidant activity among all extracts.[76] In another study, cinnamon essential oil outperformed lemon oil in terms of antioxidant activity.[77]

ANTI-INFLAMMATORY AVTIVITY

Its antioxidants, including polyphenols, cinnamic acid, and cinnamaldehyde, reduce pro-inflammatory markers (TNF- α , IL-6, CRP) and oxidative stress. This may protect against diseases like rheumatoid arthritis and improve gut health by modulating inflammatory pathways. Ethanolic extracts of *C. zeylanicum*, and *C. longa* were found to reduce inflammation in polymorph nuclear cells subjected to LPS-induced IL-6 and TNF- α . Cinnamic acid has anti-inflammatory effects in vitro, reducing IL-6 and TNF- α levels in cells.[78]

ANTICANCER ACTIVITY

The key active components, specifically cinnamaldehyde, eugenol, and other polyphenols, have been shown to inhibit cancer formation and progression at many stages.

Cinnamaldehyde has anticancer properties through a variety of interrelated processes. These effects alleviate some of the most severe manifestations of unusually rapid cell proliferation. Some of the molecular techniques include induction of apoptosis, cell cycle arrest, interruption in angiogenesis, free radical scavenging, reduction of inflammation, and interference with cellular invasion and metastasis.[79]

CONCLUSION

Cassia appears to be more effective than *C. zeylanicum* in decreasing blood glucose and promoting hypolipidemia, according to available studies. Triangular clinical trials with the most common cassia and *C. zeylanicum* are necessary, with careful consideration of sampling history, preparation, and controls. Cinnamaldehyde may have a crucial role in certain of cinnamon's bioactivities, according to preliminary studies. This may explain why cassia appears to be more potent than *C. zeylanicum*. *C. zeylanicum* demands a higher price than Cassia in the international market due to its more rounded fluorescent research suggest that cassia's higher coumarin content compared to *C. zeylanicum* may be a decisive factor in western markets. It's crucial to replicate the coumarin study on all cassia cultivars and *C. zeylanicum* barks to fully prove its benefits.

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