



BIOACTIVITY OF CINNAMON ESSENTIAL OIL

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ABSTRACT

The interest in using antifungal instead of chemical preservatives in fruits and food products has been increasing in recent years. Regarding essential oils natural and liquid secondary plant metabolites are gaining importance of their use in the protection of foods. Since, they are safe and healthy. Cinnamon bark and leaf oils are selected essential oil. The antifungal activity of essential oil are mostly depend on its chemical constituents present in it which does not allowed the fungal hyphae and mycelium to grow in certain time of period. These oils are mainly used in pharmaceutical in order to preserve certain living entities. The phytochemicals present in this plant are mostly used for antifungal, antibacterial, antihistaminic, antipyretic etc. A review provides an overview of the current literature on cinnamon essential oils mainly antifungal activity, antibacterial activity, antioxidant activity, anti-mycotoxigenic activity.

Keywords: Chemical preservative, secondary metabolites and cinnamon essential oil

INTRODUCTION

Essential oils have secondary metabolites; it has volatile, natural, and complex characteristics (Bakkali F, *et al.*, 2008). The advantages of essential oils have bioactivity in the vapour phase, their characteristics that make them attractive as possible fumigants for stored product protection (Paster *et al.*, 1991; Hammer *et al.*, 1999; Tripathi *et al.*, 2008). Essential oils are playing role in plant protect and defence mechanisms against phytopathogenic micro-organisms (MIHALIAK *et al.* 1991). According to antifungal activity, several studies have investigated for the antifungal properties of essential oils against postharvest pathogen (Giamperi *et al.* 2002).

Cinnamon tree is evergreen, it grows around 10m. The plant is popularly known as Dalchini, belongs to Lauraceae family, it contains about 250 species. These are shrubs and small to medium sized plant tree. Mostly, found in tropical rains forests where they grow at various altitudes from highland slopes to lowland forests and they occur in both marshy places and on well-drained soils, widely cultivated in Sri Lanka and India (Jantan. I.B. *et al.*, 2008). Bark is smooth and yellowish colour. Leaves are leathery, 11 to 16 cm long with pointed tips. Yellow flowers are inconspicuous with a particular odour. Fruit of this plant is a small, fleshy and berry. However, in latitudes with seasonal climatic condition and atmospheric changes, they become exceedingly rarely occurrences (Lawrence, 1967).

Cinnamon oil is spicy, sweet, and prized for its lush fragrances (Rao and Gan 2014). Cinnamon oil has bioactivities such as antibacterial, antifungal, antioxidant, anti-mycotoxigenic (Jatan. I. B., *et al.*, 2008; Yousef Naserzadeh *et al.*, 2019; Siripornvisal *et al.*, 2009; Mutullngok, A., *et al.*, 2020). Cinnamon essential oils are thought to play role in plant defence mechanism against phytopathogenic micro-organisms like fungus and bacteria (Mihaliak *et al.*, 1991). Cinnamon oil is both natural preservative and flavouring substances that are not harmful when it consumed as food products (Sukatta, U., *et al.*, 2008). Antifungal activity of cinnamon oil has been reported to inhibit the growth of moulds, yeasts and bacteria (Matan *et al.*, 2006). Cinnamon oil derived from cinnamon bark and cinnamon leaves (Siripornvisal *et al.*, 2009). Oil from cinnamon bark it commercially know as cinnamon oil, it's used as flavouring ingredient and agent in foods and drinks, as perfumery material, and in many pharmaceutical preparations and its practises for its carminative and astringent properties. Leaf oil distilled from *C. zeylanicum* used as a source of eugenol (Reynolds, 1993). The essentials of cinnamon species have also recorded subject of some studies. For example, linalool (Fujita & Fujita, 1972), camphor (Yuangzhenget *al.*, 1986), cinnamaldehyde (Fang *et*

al., 1989), 1, 8-cineole, eugenol (Wijesekera & Jayewardene, 1974), terpine-4-ol, and safrole (Biyao *et al.*, 1986) have been found and reported as major components of leaf, twig, bark, wood, and root oils of various species.

2. PHYTOCHEMICALS

The main compounds isolated and identified from *C. zeylanicum*, it belongs to two chemically classes as phenols: polyphenols and volatile phenols. Amongst polyphenols, *C. zeylanicum* contains chemical components mainly vanillic, caffeic, gallic, protocatechuic, p-coumaric, and ferulic acids (Muchuweti. M., *et al.*, 2007) (table-1). Regarding volatile components, cinnamon oil having chemical components depends on the part of the plant from which they are extracted. In cinnamon bark essential oil, cinnamaldehyde is the most represented substance, with a content ranging from 62% to 90% - 73%, depending on the type of extraction, being higher for steam distillation than Soxhlet extraction (Wong Y. C. *et al.*, 2014) (table-2), and the other minor volatile components are hydrocarbons and oxygenated compounds like β -caryophyllene, benzyl benzoate, linalool, eugenol acetate, and Cinnamyl acetate (configuration-2) (Wong Y. C. *et al.*, 2014). Cinnamon leaf oil has a main component is eugenol, with 80% concentration. Cinnamyl acetate and caryophyllene are the major components in the essential oil obtained from cinnamon fruits and flowers (table-2) (Jayaprakasha G.K., *et al.*, 1997; Jayaprakasha G.K. *et al.*, 2000; Filoche S.K. *et al.*, 2005).

Polyphenolic constituents	Structure
Vanillic acid	
Caffeic acid	
Gallic acid	
Protocatechuic	
p-coumaric	
Ferulic acids	

Table-1: polyphenolic components (Nabavi, S.F., *et al.*, 2015)

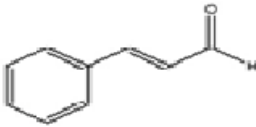
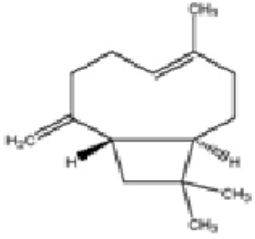
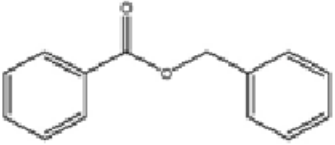

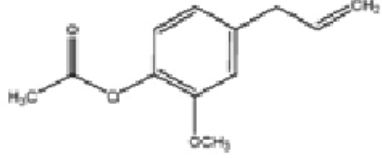
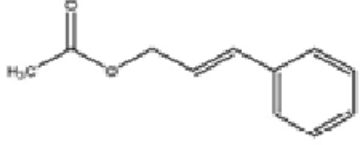
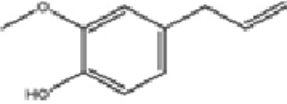
Volatile phenols	Structure
1. Cinnamaldehyde	
2. Caryophyllene	
3. Benzyl benzoate	
4. Linalool	
5. Eugenol acetate	
6. Cinnamyl acetate	
7. Eugenol	

Table-2 major and minor components (Nabavi, S.F., et al., 2015)

2. MEDICINAL PROPERTIES

Outer bark of cinnamon used as spice and several medicinal properties. Inner bark of cinnamon used as medicinal properties and it have essential oil. All over the world, cinnamon bark and leaves are used as an important spice (Rao and Gan 2014). *Cinnamon* as aromatic plant, it is not only used for cooking but they have used as medicinal properties, it also used in traditional medicine (Rao and Gan 2014). Cinnamon has mainly used as bark and powder. It can be found on the spice markets (Ravindra et al., 2003). Cinnamon has high medicinal potential and wide range of possible positive effect for human body and sources (Katarina Jeramic et al., 2019).

Medicinal uses	Cinnamon comes from a tree. People use the bark and leaves to make medicine. <ul style="list-style-type: none"> - Prevent diabetes - Prevent against Diarrhoea - Prevent infections - Protect against worm infestations - Prevent against common cold - Effective against Influenza - Effective for upset stomach - Prevent gastric problem 	(Subasinghe, S., et al., 2016)
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	<ul style="list-style-type: none"> - Prevent spasms - Prevent appetite stimulation - Effective for menstrual discomfort - Prevent against hay fever (allergic rhinitis) - Protect against yeast infection (Candidiasis) - Prevent irritable bowel syndrome (IBS) - Effective responses for food poisoning 	
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3. BIOACTIVITY OF CINNAMON OIL

Cinnamon oil has bioactivity such as: antifungal, antibacterial, antioxidant, and antimycotoxigenic activity (Mutullngok, A., *et al.*, 2020).

• **Antifungal activity of cinnamon oil**

Fungal infection caused by eukaryotic organisms and fungal spore (Filomena Nazzaro, *et al.*, 2017). Fungal cell wall may be considered as the prime target for selectively toxic antifungal agents because of cell wall have chitin structures, chitin absent in human cells. Chemical treatments are largely effective, but resistant strains and intrinsically resistance species can be developed. Cinnamon oil can represent one of the most promising natural products for fungal inhibition (Hu Y. *et al.*, 2007; kalemba, D., *et al.*, 2003). In fact, cinnamon oil many kinds of essential oils obtained from different plants, herbs and shrubs exhibited intense antifungal properties (Hu Y. *et al.*, 2007; Bakkali, F., *et al.*, 2008; Prakash, B., *et al.*, 2012; Lang, G *et al.*, 2012). Essential oils like the other phytochemicals it could attenuate the microbial growth and bio-film development through specific mechanisms (Hylgdaard, M *et al.*, 2012). To check effectiveness of a group of essential oils in a study investigating and comparing, it including spearmint, peppermint, and mainly cinnamon oils, the most effective one was found to be cinnamon essential oil against *Penicillium* spp. Moreover, it tested on *Penicillium* species. It showed considerable antifungal sensitivity to essential oils obtained from the leaf and bark of cinnamon plant (Jeong, E.J. *et al.*, 2014). *Cinnamomum zeylanicum* most effective one was indicated to be cinnamon EO with the lowest MIC values against *Aspergillus flavus*, *Aspergillus ochraceus*, and *Aspergillus niger* (Hu, F., *et al.*, 2019). Cinnamon (*Cinnamomum zeylanicum*) essential oil has most effective components due to their biological activities were indicated to be eugenol and cinnamaldehyde (Siddiqua S., *et al.*, 2015). The antifungal activity of cinnamon oil has been determined against several species of fungus, it includes *Aspergillus flavus* (Cisarova, m., *et al.*, 2016), *Aspergillus ochraceus* (Moghadam, Z.A., *et al.*, 2015; Hu, F., *et al.*, 2019), and *Aspergillus niger*, *Aspergillus oryzae* (Hu, F., *et al.*, 2019), *Aspergillus parasiticus* (Cisarova, m., *et al.*, 2016), and *Fusarium proliferatum* (Velluti, A., *et al.*, 2003). Cinnamon essential oil's inhibitory effects from *Cinnamomum cassia* (cinnamon, 78% e-cinnamaldehyde) was also proved against *Aspergillus carbonarius* (Lappa, I.K., *et al.*, 2017). In addition to *Aspergillus* species, *Fusarium verticilloides* was also investigated in terms of its sensitivity against cinnamon oils, it includes different kind levels of cinnamaldehyde, the main component of cinnamon oil, as 85% and 99%. If cinnamon oil has higher inhibitory effect, cinnamaldehyde concentration was higher (Jeong, E.J. *et al.*, 2014).

Table-3: Overview of antifungal properties of cinnamon essential oils (Mutullngok, A., *et al.*, 2020).

Essential oil from	Fungal culture	Method	MIC ¹ /inhibition	References
Cinnamon (cinnamon) sp.	<i>Aspergillus ochraceus</i>	Macro dilution	0.078 μL/ml	(Moghadam, Z.A., <i>et al.</i> , 2015)
Cinnamon (cinnamon) sp.	<i>Fusarium verticilloides</i>	Semisolid agar antifungal susceptibility technique	60 μL/L	(Xing, F., <i>et al.</i> , 2014)
Cinnamon (cinnamon) sp.	<i>Penicillium</i> spp., <i>Cladosporium</i> spp.	Disc diffusion	100% inhibition at 20 μL	(Jeong, E.J. <i>et al.</i> , 2014)

<i>Cinnamomum camphora</i>	<i>Aspergillus niger</i> , <i>Aspergillus oryzae</i> , <i>Aspergillus ochraceus</i>	Gradient plate	2mg/mL	(Hu, F., <i>et al.</i> , 2019)
<i>Cinnamomum cassia</i>	<i>Aspergillus flavus</i>	Broth micro dilution	62.5 µg/mL	(Pekmezovic, M., <i>et al.</i> , 2015)
<i>Cinnamomum cassia</i>	<i>Aspergillus carbonarius</i>	Poisoned food technique	100% inhibition at 50-100 µL/L	(Lappa, I.K., <i>et al.</i> , 2017)
<i>Cinnamomum cassia</i>	<i>Aspergillus flavus</i> , <i>Aspergillus carbonarius</i> , <i>Penicillium viridacatum</i>	Inhibitory zone method	1.67>5 µL/ml	(Wang, H., <i>et al.</i> , 2018)
<i>Cinnamomum zeylanicum</i>	<i>Aspergillus niger</i> , <i>Aspergillus oryzae</i> , <i>Aspergillus ochraceus</i>	Gradient plate	0.062-0.125 mg/mL	(Hu, F., <i>et al.</i> , 2019)
<i>Cinnamomum zeylanicum</i>	<i>Botrytis cinerea</i> , <i>Penicillium expansum</i>	Broth micro dilution	625-1250 mg/mL	(Nikkhah, M., <i>et al.</i> , 2017)
<i>Cinnamomum zeylanicum</i>	<i>Aspergillus flavus</i> , <i>Aspergillus parasiticus</i>	Micro atmosphere	100% inhibition at 500 µL/L	(Cisarova, m., <i>et al.</i> , 2016)

• **Antibacterial activity of cinnamon oil**

Table-4: Overview of antibacterial activities of cinnamon essential oil (Mutullngok, A., *et al.*, 2020).

Essential oil from	Bacterial culture	Method	MIC ¹	References
<i>Cinnamomum camphora</i>	<i>Bacillus subtilis</i> , <i>Escherichia coli</i> , <i>Staphylococcus aureus</i> , <i>Salmonella typhimurium</i>	Micro dilution broth	2-4 mg/mL	(Tu, X.F., <i>et al.</i> , 2018)
<i>Cinnamomum zeylanicum</i>	<i>Bacillus subtilis</i> , <i>Escherichia coli</i> , <i>Staphylococcus aureus</i> , <i>Salmonella typhimurium</i>	Micro dilution broth	0.12-.025 µg/mL	(Tu, X.F., <i>et al.</i> , 2018)
<i>Cinnamomum zeylanicum</i>	<i>Bacillus cereus</i> , <i>Escherichia coli</i> , <i>Escherichia coli</i> O157:H7, <i>Pseudomonas aeruginosa</i> , <i>P. fluorescens</i> , <i>P. putida</i> , <i>Pectobacterium carotovorum</i> , <i>Salmonella enterica subsp. Enterica</i> , <i>Staphylococcus aureus</i>	Broth dilution	100-400 µg/mL	(Clemente, L., <i>et al.</i> , 2016)

<i>Cinnamomum zeylanicum</i>	<i>Bacillus cereus, Escherichia coli, Listeria monocytogenes, Staphylococcus aureus, Pseudomonas aeruginosa, Salmonella typhimurium</i>	Micro dilution	72.27-14.63 $\mu\text{L}/\text{mL}$	(Purkait, S., et al., 2020)
<i>Cinnamomum zeylanicum</i>	<i>Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa, P. putida, Staphylococcus aureus</i>	Broth macro dilution	1.25 $\mu\text{L}/\text{mL}$	(Lalami, A.E.O., et al., 2019)
<i>Cinnamomum zeylanicum</i>	<i>Listeria monocytogenes, Staphylococcus aureus, Salmonella enteritidis, Campylobacter jejuni</i>	Broth dilution	0.06-7.25 $\mu\text{L}/\text{mL}$	(Pesavento, G., et al., 2015)

• **Antioxidant activity**

Table-5: overview antioxidant properties of cinnamon essential oil (MutulIngok, A., et al.,

Essential oil from	Most abundant compounds	Method	Results	References
<i>Cinnamomum zeylanicum</i> Blume (cinnamon)	Cinnamaldehyde (77.34%), trans-cinnamyl acetate (4.98%), 1,4-benzenedicarboxylic acid (3.55%), 1,8-cineole (3.19%), α -pinene (2.6%)	Phosphomolybdenum assay DPPH H_2O_2^5	108.75mg of EO/equivalent to 1 mg of vitamin c in terms of antioxidant power 21.3% inhibition 55.2% inhibition	(Kallel, I., et al 2019)
<i>Cinnamomum zeylanicum</i> Blume (cinnamon)	(E)- Cinnamaldehyde (81.39%), (E)- cinnamyl acetate (4.2%), (Z)- Cinnamaldehyde (3.42%), 1,8-cineole (1.9%), dihydrocinnamaldehyde (1.85%)	Phosphomolybdenum assay CUPRAC FRAP DPPH ABTS	111.46mg TE _s /g sample -9.82mg TE _s /g sample 3.49% inhibition (0.30mg TE _s /g sample) 19.20% inhibition (1.03mg TE _s /g sample)	(Tepe, A.S., et al., 2020)
<i>Cinnamomum zeylanicum</i> (cinnamon)	Cinnamaldehyde (66.2%), eugenol (9.57%), β -caryophyllene (7.21%), 1,2-benzenedicarboxylic acid, mono(2-ethylhexyl) ester (3.27%)	DPPH β -carotene linoleic acid bleaching assay Ferrous (Fe^{2+}) ion chelating efficacy	4.62-57.56% inhibition lower inhibitory activity than clove oil and black pepper 2.13-	(Purkait, S. et al., 2018)

			43.86% activity	
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• **Anti- mycotoxigenic activity**

Table-6: overview anti mycotoxigenic properties of cinnamon essential oil (Mutullngok, A., et al., 2020).

Essential oil forms	EO concentration	Mycotoxins	Mycotoxin inhibition	Method	References
Cinnamon	140 µg/mL	Fum B1	66.65	ELISA	(Xing, F. et al., 2014)
Cinnamon	500 µg/g	DON ⁵ ZEA ⁶	100	HPLC,LOD:NI	(Marin, S. et al., 2004)
Cinnamon	210-280 µg/mL	Fum ⁷ B1	88-93.35	ELISA,LOD:NI	(Xing, F., et al., 2014)
<i>Cinnamomum cassia</i>	50-75 µL/L	OTA ⁸	58-90	HPLC,LOD:1ng/g	(Lappa, I.K., et al., 2017).
<i>Cinnamomum jensenianum</i> Hand.-Mazz	1-8 µL/mL	AF B1	31.6-100	TLC-UV, LOD:NI	(Tian, J., et al., 2012)
<i>Cinnamomum zeylanicum</i> , Sri Lanka (Leaf)	100-200 µL/mL	DON	8.08-13.74	HPLC, LOD:NI	(Perczek, A., et al., 2019)
<i>Cinnamomum zeylanicum</i> , Sri Lanka (Leaf)	100-200 µL/mL	ZEA	13.23-16.87	HPLC, LOD:0.01 µg/mL	(Perczek, A., et al., 2016)
<i>Cinnamomum zeylanicum</i> , Indonesia (bark)	100-200 µL/mL	DON	41.55-46.92	HPLC, LOD:NI	(Perczek, A., et al., 2019)
<i>Cinnamomum zeylanicum</i> , Indonesia (bark)	100-200 µL/mL	ZEA	79.79-89.29	HPLC, LOD:0.01 µg/mL	(Perczek, A., et al., 2016)
<i>Cinnamomum jensenianum</i> Hand.-Mazz	1-8 µL/mL	AF B1	31.6-100	TLC-UV,LOD:NI	(Tian, J., et al., 2012)

4.CONCLUSION

According to multipurpose source, cinnamon oil is the finest spice oil for phytochemicals screening, research, and pharmaceutical practices. Cinnamon plant's both parts leaf and bark extract are considered as essential oil. It has strong activity against bacteria and fungus. Cinnamon oil has strong bioactivity such as antifungal, antimicrobial, antioxidant, anti-



mycotoxigenic activities than other essential oil. Hence it can be further explored for its medicinal properties.

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