

International Journal of Pharmaceutics and Drug Analysis

Availabe at www.ijpda.com

ISSN: 2348:8948

Dalchini (*cinnamomum zeylanicum*): a versatile spice with significant therapeutic potential Shifali Thakur, Bhawna Walia, Gitika Chaudhary* Shuddhi Ayurveda, Jeena Sikho Lifecare Pvt. Ltd. Zirakpur 140603, Punjab

Received: 08 May 2021 Revised: 20 June 2021 Accepted: 26 June 2021

Abstract

Cinnamomum zeylanicum is a widely utilized condiment for its therapeutic uses since ancient times. It is indigenous to Sri Lanka and Southern India. Cinnamon is an ancient spice which belongs to the Lauraceae family. In the modern era, it is widely utilized as candies, chewing gums, mouthwash and toothpaste for commercial benefits. It is a well-considered plant which is used for treating many diseases in a traditional system like Ayurveda and the Folk system of medicine. Cinnamomum zeylanicum is utilized in many polyherbal formulations for curing various ailments. The plant is enriched with many volatile oils which mainly consist of cinnamaldehyde, cinnamic acid and cinnamate. Eugenol is the active principle constituent associated with many biological activities. The main therapeutic actions of the plant are antimicrobial, wound healing, antidiabetic, anti-HIV, anti-anxiety and anti-Parkinson's. The current review has summarized the therapeutic and pharmacological value of Cinnamomum zeylanicum along with its utilization in the Folklore medicinal system.

Keywords: Dalchini, Cinnamaldehyde, Anti-Parkinson's, Antimicrobial, Ayush-Kwath.

This article is licensed under a Creative Commons Attribution-Non Commercial 4.0 International License. Copyright © 2021 Author(s) retain the copyright of this article.



*Corresponding Author

Gitika Chaudhary

Email: shuddhi.research@jeenasikho.co.in
DOI: https://doi.org/10.47957/ijpda.v9i2.467

Produced and Published bySouth Asian Academic Publications

Introduction

Cinnamon herb is used by different cultures around the world for several centuries. The tropical evergreen plant Cinnamon has two varieties; *Cinnamonum zeylanicum* (CZ) and *Cinnamon cassia* (CC) and obtained from the inner bark [1]. The plant is also named as Cinnamonum aromaticum/Chinese cinnamon [2]. In Ayurveda, it is utilized for the respiratory system, digestive and gynecological disorders. The volatile oils are present in each parts of the plant such as bark, leaf and root barks. There are more than 200 species comprised of genus *Cinnamonum* out of which 20 species occurred in India [3]. Each part of the plant possesses the same hydrocarbons in varying proportions, with primary constituents such as cinnamaldehyde (Bark), eugenol

(leaf), and camphora (root). Camphor, is the active compound extracted from the root part of the plant and has commercial value unlike the leaf and bark [4]. In Sri-Lanka and India, plant is also called 'true cinnamon [5]. There are main 3 constituents of the essential oils of Cinnamomum zeylanicum i.e. trans-cinnamaldehyde, eugenol, and linalool which represent 82.5% of the total composition [6]. The major 2 components of Cinnamomum zeylanicum plant are Cinnamaldehyde and eugenol [7]. Cinnamon is considered as a potent neuroprotective agent [8] as well as a medicine for the treatment of type 2 diabetes mellitus in the conventional Chinese system [9]. Many studies demonstrated the pharmacological properties of cinnamon such as antiinflammatory, anti-microbial, blood glucose, reducing cardiovascular, increasing cognitive function and anticarcinogenic [10-11]. Coumarin is the chemical constituent present in trace amount in C. zeylanicum [12]. Presence of coumarin is the main difference between CC and CZ. The percentage of coumarin is very high in CC as compared to CZ. The vernacular names and taxonomical classification are mentioned in table no. 01 and table no. 02 respectively.

Table 01. Vernacular names of Cinnamomum zeylanicum (Dalchini)

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

Table 02: Morphological Classification of Cinnamomum zeylanicum (Dalchini)

Taxonomical Rank	Taxon
Kingdom	Plantae
Phylum	Magnoliophyta
Class	Magnoliopsida
Order	Laurales
Family	Lauraceae
Genus	Cinnamomum
Species	Zeylanicum

Botanical Distribution of Cinnamomum zeylanicum (Dalchini)

Cinnamomum zeylanicum (Dalchini) is an evergreen tropical plant attaining the height of about 6-8 meters with thick, smooth, reddish-brown bark. The opposite or sub-opposite leaves are glabrous, ovate and lanceolate, hard and coriaceous. Leaves are shinning from above, slightly pale beneath with 3-5 main nerves. Petiole flattened up to ½-1 inch. Flowers are in axillary or sub-terminal cymes or panicles. Fruit is ovate or oblong, about 1.5-2cm long, minutely apiculate, dry or slightly fleshy and dark purple in color.



Fig 01: Cinnamomum zeylanicum (Dalchini)

Geographical Distribution of Cinnamomum zeylanicum (Dalchini)

This plant is indigenous to Sri Lanka, India, and Myanmar (Burma) and is also cultivated in South America and the West Indies. Sri Lanka is known as best Cinnamomum growing country. Sri Lanka and Seychelles are also producer of best quills. This country also produced Cinnamon leaf oil through distillation [13-15].

Phytochemical constituents of Cinnamomum zeylanicum (Dalchini)

Cinnamon contains numerous resinous compounds, including cinnamaldehyde, cinnamate, cinnamic acid, and numerous essential oils. Cinnamon has a spicy taste and pungent fragrance due to cinnamaldehyde compound [16]. There are various cinnamon essential trans-cinnamaldehyde, oils i.e. cinnamyl L-borneol, caryophyllene eugenol, caryophyllene, L-borneol acetate, E-nerolidol, alphacubebene, alpha-terpineol, terpinolene, and alpha thujene [17-18]. Cinnamomum zeylanicum consists class of chemical compounds like aldehydes, alcohols, esters, phenols, acids, monoterpenes, diterpenes, sesquiterpenes, benzopyrones, hydrocarbons flavonoids. Cinnamaldehyde, methoxycinnamaldehyde, hydrocinnamic, benzaldehyde, vanillin, cuminaldehyde, benzenepropanal, 2-methyl-3-phenyl-propanal, citronellal are the aldehydes present in the bark essential oil of C. zeylanicum. The alcohols compounds extracted from the Cinnamomum zeylanicum plant are: Cinnamyl alcohol, α -terpineol, linalool, α -Bisabolol; Esters compounds are cinnamyl acetate, cinnamaldehyde diethyl acetal, methyl cinnamate, hydrocinnamyl acetate, benyl benzoate, bornyl acetate and phenols are eugenol, pyrogallol. Cinnamic acid, ferulic acid, caffeic acid, gallic acid, protocatechuic acid, oleic acid and phydrobenzoic acid are also present in different parts of the plant. Cinnamomum zeylanicum consists of various monoterpenes including p-cymene, limonene, α terpinene, α -pinene, camphene, camphor, 1,4-cineole, β pinene, β-Phellandrene, α -phellandrene and 3-carene; Diterpenes such as cinnzeylanine, cinnzeylanol and Sesquiterpenes i.e. humulene, caryophyllene oxide, βcaryophyllene, α -Muurolene, α -copaene, cedrene, α tumerone, β-tumerone, α -cadinol, t-candinol, calamenene and α-Ylangene isolate mostly from the plant leaves [19-20]. There are many essential oils, so the isolation and separation process can be long and tedious

[21]. Hydro-distillation method is the most commonly used method for separation. In this, chemical compounds are extracted from the bark, leaves, fruits, buds, and stalks of the plant [22-28]. The method is a rapid and less expensive. The disadvantage of this method is chemical alteration and the heat-sensitive compounds gets easily destroyed [29]. For completing this limitation supercritical fluid extraction method was introduced. This method is appropriate for the isolation of thermally and chemically unstable compounds. Eugenol is the main compound present in the leaves of cinnamon while α-ylangene, methyl, and ethyl cinnamate are also present in the leaf oil [30]. Benzyl benzoate in bark oil and terpinene-4-ol in root-bark oil were also present in cinnamon. The analysis of different parts of *C. zeylanicum* such as leaf, stem bark, and root bark oils indicated 72 compounds out of which 32 compounds were reported in a study by Jayaprakasha and Jagan Mohan Rao. The reported new compounds were 11 monoterpenes, 4 sesquiterpenese 2 aliphatic, and 15 aromatic compounds. In addition, Isogai et al., also reported two new compounds named cinnzeylamine and cinnzeylanol from the dried bark of *C. zeylanicum* [31]. Vermin et al., reported the presence of p-cymene (21.35%) and eugenol (16.7%) by analyses of *C. zeylanicum* leaves oil. Forty-seven chemical constituents were identified using GC-MS analysis of essential oils from cinnamon leaf grown in India [32]. Some structures of major compounds of C. zeylanicum are shown in fig 02.

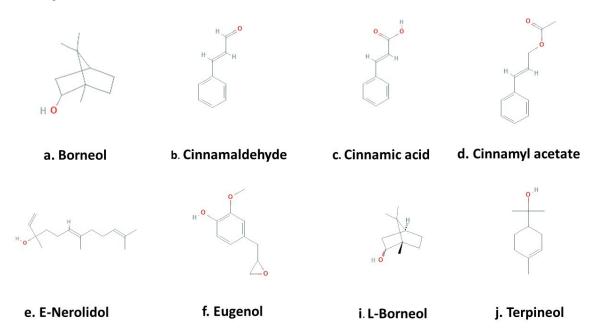


Fig 02: Some structures of major chemical constituents of C. zeylanicum

Traditional and Modern View

View: Avurvedic Dalchini (Cinnamomum zeylanicum) is a most common aromatic herb with various medicinal properties. Cinnamon is the dried inner brown bark of a cinnamon tree. The flavor of Dalchini is owing to an aromatic essential oil that is about 0.5 to 1% of its composition. The plant possesses amazing medicinal activities like antifungal, antioxidant, antibacterial, lowering cholesterol level in the body, gastrointestinal tract infection and mentioning sugar level and many more. This herb manages Vata and pitta component of body [33-34]. Table no. 03 represents the rasa panchak of Dalchini plant.

Table 03: Rasa Panchak of Cinnamomum zeylanicum (Dalchini)

Sanskrit/English	Sanskrit/English
Rasa/Taste	Katu, Madhura, Tikta/ Pungent,
	Bitter, Sweet
Guna /Physical	Laghu, Rooksha, Tikshna/Light,
Property	Dry, Piercing
Virya/Potency	Ushana/Hot
Vipaka/Metabolic	Katu/Pungent
Properties	

Some Major Ayurvedic Medicinal Uses of Dalchini are:

• It provides relief in sore throat, influenza, common cold and headache.

- It is also used as an expectorant and have antitubercular activity.
- It is a natural remedy in the case of rheumatoid arthritis.
- Also helpful in reducing cholesterol levels and tends to strengthen the heart muscles.
- It provides relief in menstrual pain. A study says women should drink a cup of warm cinnamon water every day it helps in experiencing less pain during menstruation for a short duration.

Dalchini is utilized for good digestion and possess antiinflammatory properties.

Reported studies also demonstrated the use of dalchini in neurodegenerative diseases like Alzheimer's, Parkinson's diseases and, multiple sclerosis.

Various Ayurvedic Product of Cinnamomum zeylanicum

Madatyahar Churna, Kaas-har Churna, Arjun Tea, Praanrakshak Churna, Stholyantak Churna, Detox tea, Chanderprapha Vati.

Dalchini is also utilized against Covid-19. Ayush-Kwath is the ayurvedic herbal formulation used to improve immunity and combat infection. The Ministry of Ayush, Government of India has prescribed "Ayush Kwath" in Covid patients to improve their immunity. The formulation consists of various medicinal plants i.e. Tulsi, Dalchini, Sunthi and Marich. These medicinal herbs possess immune-modulatory effects, antiviral, antioxidant, anti-inflammatory, antiplatelet, anti-atherosclerotic, hepatoprotective and renoprotective properties. All these properties seem to be effective in immune-regulation for controlling viral infections like Covid-19 [35].

b. Folk View: From ancient times, cinnamon is used as a condiment and flavoring agent [36]. Some reports suggested that it improves the health of the colon, thereby reducing the risk of colon cancer [37]. It is used to prevents bleeding [38]. Cinnamon increases the blood circulation in the uterus and advances tissue regeneration [39]. The herb has many traditional properties including antimicrobial [40-43], antifungal [44], antioxidant [45-49], antidiabetic [50-55], anti-inflammatory antitermitic [57], nematicidal [58], mosquito larvicidal [59], insecticidal [60] and anticancer agent [61]. Cinnamon has also been traditionally utilized for toothaches, dental problems, oral microbiota and bad breath [62-63].

Modern View: Many chemical drugs are in the market against various diseases but still, plant based medicines are considered for their negligible adverse impacts and least toxicity. As we all know that chemical drugs are action-oriented for specific disorders, while plant extracts work synergistically and possess more than one therapeutic activity. Singh et al., reported that one pathway activated via cinnamon is involved in other complications too, so treatment of one disease can prevent the other diseases automatically [64]. Adulteration and substitution are the most common malpractices in any market of crude drugs. Therefore, the authentication of medicinal plants is very important [65]. There are several factors that directly or indirectly promote the quality degradation of herbal medicine by unavailability of required species, similar morphological appearance, conflict in vernacular names of herbal plants mishandling and improper storage and deliberate substitution [66-69]. Many other threats have the ability to create hardship for herbal drug markets such as lack of skilled traditional AYUSH professionals having a scientific background, insufficient research and development activities, lack of regulatory standards and documented information on herbal plants and influence of western medication etc. [70] Some standardization can be initiated by proper pharmacognostical study of drug as it provides whole information about crude drugs [71].

Reported Pharmacological and Therapeutic Activities of *Cinnamomum zeylanicum* Antimicrobial Activity

Various studies states that Cinnamomum zeylanicum is a well-documented antimicrobial agent because of its strong hydrophobic nature [72-73]. Naveed et al., evaluated the antimicrobial activity of essential oils of C. zeylanicum along with three other herbs i.e. Cuminum cyminum, Amomum subulatum and Syzygium aromaticum via broth micro-dilution method against Salmonella typhi, Salmonella para-typhoid, Escherichia coli, Bacillus staphylococcus aurens, licheniformis Pseudomonas fluorescens. The finding revealed potent antimicrobial activity of C. zeylanicum against all bacteria's than the other three herbs [74]. Abdalla and Abdelgadir also reported antimicrobial activity of methanol, ethanol, petroleum ether and ethyl acetate extracts of C. zeylanicum against staphylococcus aureus, Bacillus subtilis, Escherichia coli and Pseudomonas

aeruginosa. Result showed potent antimicrobial activity of ethyl acetate against *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa* while petroleum ether extract had maximum sensitivity against *Bacillus subtilis* [75]. Another study by Mith et al., tested 15 essential oil extracts from 15 different plants against various bacterial strains. Cinnamon essential oil showed more potent antibacterial activity than others [76]. Utchariyakiat et al. evaluated that cinnamon extract has antibacterial activity via agar well diffusion assay. The chloroform extract was found to be a more potent antimicrobial agent than methanol extract [77].

Antioxidant Activity

Saranya et al., reported antioxidant activity of hexane, chloroform and methanol extract of cinnamon, black pepper, ginger turmeric via DPPH, phosphomolybdate and ferric reducing antioxidant power assay. Methanol extract of cinnamon showed strongest antioxidant activity than others [78]. Another study by Elgendy et al., evaluated strongest antioxidant activity of cinnamon essential oil than lemon oil [79]. Beji et al. reported antioxidant activity of cinnamon powder in alloxan-induced diabetic rats. antioxidant enzymes such as glutathione, peroxidase, catalase and superoxide dismutase present in the cinnamon powder significantly increased and reduce the blood glucose level in the rats [80].

Anti-inflammatory Activity

Durak et al., reported anti-inflammatory activity of the methanolic and ethanolic extracts of C. zeylanicum by inhibiting the lipoxygenase (LOX) enzyme activity in the mice. The mice were artificially induced with collagenmediated arthritis. Both extracts were found to reduce the production of pro-inflammatory cytokines in the model [81]. Qabaha et al., evaluated the anti-inflammatory activity of ethanolic extract of C. zeylanicum along with C. longa in lipopolysaccharide (LPS)-induced interleukin-6 (IL-6) and tumor necrosis factor- α (TNF- α) of polymorph nuclear cells. The invitro study showed anti-inflammatory activity of cinnamic acid via decreasing the level of IL-6 and TNF- α in the cells [82].

Anticancer Activity

In-vitro study by Goyal et al., examined the anticancer activity of the water-soluble polysaccharide and other different extracts of cinnamon against macrophage cell lines via cell proliferation assay. The cinnamon

polysaccharide fraction was found to possesses more immunostimulatory effects as compared to other cinnamon extracts [83]. Mehrin and Salem studied various herbal plants including C. zeylanicum for their antiaflatoxin activity on 360 randomly selected fishes. The result showed that C. zeylanicum has a significant effect against aflatoxin [84]. Bhagwathey and Latha mentioned in their study that various types of ulcers and cancers were treated with the C. zeylanicum plant [85]. Ezzat et al., reported anticancer activity of cinnamon bark aqueous extract on 7,12-dimethylbenz anthracene (DMBA) induced oral cancer in sixty male Syrian hamster's cheek pouch (HCP) mucosa via various cytotoxicity assay such as 3-(4,5-di-methlthiazol-2yl)-2,5diphenyl tetrazolium bromide (MTT) assay, DNA fragmentation assay, etc. The finding revealed that cinnamon aqueous extract significantly suppressed oral cancer progression [86].

Antidiabetic Activity

Shokri et al., reported antidiabetic activity of methanol extract of cinnamon along with 50 green teas in 50 streptozotocin (STZ) induced diabetic rats. The treatment was 6-week long. After the treatment, a significant reduction in glucose levels in the rats were found. The extracts have shown a synergistic effect to balance diabetes [87]. Elwahab evaluated antihyperglycemic effect of C. zeylanicum and ginger in 40 adult albino male rats. The finding revealed that C. zeylanicum was more effective against diabetes than ginger [88]. El-Desoky et al., reported antidiabetic activity of aqueous extract of cinnamon in alloxaninduced diabetic rats. The rats were administered with different doses (200, 400,600 and 1200 mg/kg) of cinnamon aqueous extracts for 30 days. After 30 days of treatment, a significant reduction in FBS, HDL, cholesterol, LDL, cholesterol, triglucerides and serum contents were observed. The result showed that 200mg/kg of the dose has higher antidiabetic effects than others [89]. Li et al., evaluated the antidiabetic activity of cinnamon in diabetic mice. The mice were induced with streptozocin. Cinnamon was administered in mice for 14 days. Later, diabetic mice were evaluated via glucose oxidase (GOD) and radioimmunoassay (RIA). Result revealed that cinnamon maintains the blood glucose level and insulin level in the rats [90].

Wound Healing Activity

Farahpour and Habibi evaluated ethanolic extract of cinnamon for wound healing property in mice. The mice

were administered with 1.5% and 3% of cinnamon extract for 14 days. Result showed that 3 % cinnamon extract has significant wound healing property [91]. Ahmadi et al., reported wound healing property of cinnamon oil in an artificial wound-induced mice model. The models were treated with the ointment which contains 2% and 4% of essential oil of cinnamon. Cinnamon essential oil was found to enhances the mRNA levels of insulin-like growth factor, fibroblast growth factors and vascular endothelial growth factor (VEGF) [92].

Anti-HIV Activity

Semenya et al., reported that *C. zeylanicum* was effective against acquired immunodeficiency syndromes (AIDS). In the study, 26 plants were used to treat HIV/AIDS. Out of 26 plants, *Burkea Africana*, *Citrullus lanatus*, *Cinnamomum zeylanica*, *Euclea crispa*, *Elephantorrhiza elephantina*, *Euphorbia maleolens*, *Geigeria aspera*, *Plectranthus ciliates*, *Sarcostemmaviminale*, *Zanthoxylum capense* and *Zanthoxylum humile* were recorded for the treatment of HIV/AIDS [93].

Antianxiety and Antidepressant Activity

Sohrabi et al., evaluated that anti-anxiolytic and antidepressant activity of cinnamon essential oil. They carried various tests like forced swim test (FST), tail suspension test (TST) to determine the antidepressant activity of Cinnamon essential oil. Elevated plus maze test (EPM) and open field test were also carried out to determine the anti-anxiety activity of CEO. The finding revealed that CEO possesses both anti-depressant and anti-anxiety activity in rats [94]. Another study reported antianxiety and anti-depressant activity of the cinnamon hydroalcoholic extract in lead acetate-induced rats. The dose of 200 mg/kg of cinnamon extract was administered for 30 days. FST test revealed that cinnamon has significantly reduced the immobility time delay and enhanced the total time of immobility and EPM test revealed the significant reduction of open arms entries. Therefore, cinnamon extract has both antianxiolytic and antidepressant activity [95].

Anti-Parkinson Activity

Khasnavis et al., reported antiparkinsonian effects of *Cinnamomum zeylanicum* in MPTP-intoxicated mice. The dose of 100 μ l of cinnamon powder solubilized in 0.5% methylcellulose (MC) was administered in mice. It was observed that dose has stimulated the sodium benzoate production in the brain and brain cells of mice models.

Result suggested that cinnamon is beneficial for the treatment of Parkinson's disease [96].

Toxicological Studies

Isaac et al., examined the consumption of cinnamonassociated intraoral allergic contact dermatitis (ACD). Cinnamic aldehyde is widely used as a flavoring agent in foods and dentifrices. However, intraoral allergic contact dermatitis (ACD) induced by cinnamon agents has been occasionally reported [97]. Cardoso et al., reported the toxicity of cinnamic acid, a compound derived from cinnamon essential oil. The study revealed that the toxicity of the compounds was dosedependent when added to perfumery and oral care products [98].

Conclusion

Cinnamomum zeylanicum is an extensively utilized medical herb for numerous pharmacological potential. This herb is included in almost each medication system worldwide. Several reports have mentioned numerous properties of Cinnamomum zeylanicum like anti-diabetic, antimicrobial, antioxidant, anti-inflammatory anticancer. Each of these properties plays a key role in advancement of human health. Eugenol, cinnamaldehyde, cinnamyl acetate, copane and camphor are present as major constituents of the Cinnamomum zeylanicum plant. Cinnamaldehyde has been extensively explored for its pharmacological actions0. Each aspect of the plant from morphological description to phytochemical profile and therapeutic action has been thoroughly explored in the present study.

Conflict of Interest

None

Funding

No funding.

Author Contribution

We declare that this work was done by the authors named in this article and all liabilities pertaining to claims relating to the content of this article will be borne by the authors. Dr. Gitika Chaudhary drafted the article and contributed in writing Ayurvedic view of the article. Shifali Thakur contributed in drafting and writing pharmacological portion of plant. Bhawna Walia contributed in data collection and writing the paper.

References

- Paranagama PA, Wimalasena S, Jayatilake GS, Jayawardena AL, Senanayake UM, Mubarak AM. A comparison of essential oil constituents of bark, leaf, root and fruit of cinnamon (Cinnamomum zeylanicum Blum) grown in Sri Lanka. Journal of the National Science Foundation of Sri Lanka. 2001 Dec 27;29(3-4).
- The Wealth of India (1992). A Dictionary of Indian Raw Materials and Industrial Products, Publications and Information Directorate, New Delhi, India, p. 582.
- 3. Sastri BN. The wealth of India, raw materials. CSIR, New Delhi. 1962;6:439.
- 4. Paranagama PA, Wimalasena S, Jayatilake GS, Jayawardena AL, Senanayake UM, Mubarak AM. A comparison of essential oil constituents of bark, leaf, root and fruit of cinnamon (Cinnamomum zeylanicum Blum) grown in Sri Lanka. Journal of the National Science Foundation of Sri Lanka. 2001 Dec 27;29(3-4).
- Jayaprakasha GK, Rao LJ. Chemistry, biogenesis, and biological activities of Cinnamomum zeylanicum. Critical reviews in food science and nutrition. 2011 Jul 1;51(6):547-62
- Chericoni S, Prieto JM, Iacopini P, Cioni P, Morelli I. In vitro activity of the essential oil of Cinnamomum zeylanicum and eugenol in peroxynitrite-induced oxidative processes. Journal of agricultural and food chemistry. 2005 Jun 15;53(12):4762-5.
- Wang HF, Wang YK, Yih KH. DPPH freeradical scavenging ability, total phenolic content, and chemical composition analysis of forty-five kinds of essential oils. Journal of cosmetic science. 2008 Nov 1;59(6):509-22.
- 8. Khasnavis S, Pahan K. Sodium benzoate, a metabolite of cinnamon and a food additive, upregulates neuroprotective Parkinson disease protein DJ-1 in astrocytes and neurons. Journal of neuroimmune pharmacology. 2012 Jun;7(2):424-35.
- Kim SH, Hyun SH, Choung SY. Anti-diabetic effect of cinnamon extract on blood glucose in db/db mice. Journal of ethnopharmacology. 2006 Mar 8;104(1-2):119-23.
- Ouattara B, Simard RE, Holley RA, Piette GJ, Bégin A. Antibacterial activity of selected fatty acids and essential oils against six meat

- spoilage organisms. International journal of food microbiology. 1997 Jul 22;37(2-3):155-62.
- 11. Gruenwald J, Freder J, Armbruester N. Cinnamon and health. Critical reviews in food science and nutrition. 2010 Sep 30;50(9):822-34.
- 12. European Food Safety Authority (EFSA). Coumarin in flavourings and other food ingredients with flavouring properties-Scientific Opinion of the Panel on Food Additives, Flavourings, Processing Aids and Materials in Contact with Food (AFC). EFSA Journal. 2008 Oct;6(10):793.
- 13. De Guzman CC, Siemonsma JS. Plant resources of South-East Asia no 13: spices. Backhuys Publishers; 1999.
- 14. Coppen JJ. Flavours and fragrances of plant origin. Fao; 1995.
- 15. Ravindran PN, Nirmal-Babu K, Shylaja M, editors. Cinnamon and cassia: the genus Cinnamonum. CRC press; 2003 Dec 29.
- 16. Senanayake UM, Lee TH, Wills RB. Volatile constituents of cinnamon (*Cinnamomum zeylanicum*) oils. Journal of Agricultural and Food Chemistry. 1978 Jul;26(4):822-4.
- 17. Singh G, Maurya S, DeLampasona MP, Catalan CA. A comparison of chemical, antioxidant and antimicrobial studies of cinnamon leaf and bark volatile oils, oleoresins and their constituents. Food and chemical toxicology. 2007 Sep 1;45(9):1650-61.
- 18. Y.-T. Tung, M.-T. Chua, S.-Y. Wang, and S.-T. Chang, "Anti inflammation activities of essential oil and its constituents from indigenous cinnamon (Cinnamomum osmophloeum) twigs," Bioresource Technology, vol. 99, no. 9, pp. 3908–3913, 2008.
- Marston A, Hostettmann K. Modern separation methods. Natural product reports. 1991;8(4):391-413.
- Malsawmtluangi L, Nautiyal BP, Hazarika T, Chauhan RS, Tava A. Essential oil composition of bark and leaves of Cinammoum verum Bertch. & Presl from Mizoram, North East India. Journal of EssEntial oil rEsEarch. 2016 Nov 1;28(6):551-6.
- 21. Singh N, Rao AS, Nandal A, Kumar S, Yadav SS, Ganaie SA, Narasimhan B. Phytochemical and pharmacological review of Cinnamomum verum J. Presl-a versatile spice used in food

- and nutrition. Food Chemistry. 2021 Feb 15;338:127773.
- 22. Begum J, Yusuf M, Chowdhury JU, Husain MM, Hossain ME, Ahmed S, Anwar MN. Composition and antifungal activity of essential oil of leaves of Cinnamomum verum Presl. grown in Bangladesh. Indian Perfumer. 2007;51(2):69.
- 23. Dongmo PM, Tatsadjieu LN, Tchoumbougnang F, Sameza ML, Dongmo BN, Zollo PH, Menut C. Chemical composition, antiradical and antifungal activities of essential oil of the leaves of *Cinnamomum zeylanicum* Blume from Cameroon. Natural product communications. 2007 Dec;2(12):1934578X0700201219.
- Jayaprakasha GK, Jagan Mohan Rao L, Sakariah KK. Volatile constituents from Cinnamomum zeylanicum fruit stalks and their antioxidant activities. Journal of agricultural and food chemistry. 2003 Jul 16;51(15):4344-8.
- 25. Jayaprakasha GK, Rao LJ, Sakariah KK. Chemical composition of the volatile oil from the fruits of *Cinnamomum zeylanicum* Blume. Flavour and fragrance journal. 1997 Sep;12(5):331-3.
- Jayaprakasha GK, Rao LJ, Sakariah KK. Chemical composition of volatile oil from Cinnamomum zeylanicum buds. Zeitschrift für Naturforschung C. 2002 Dec 1;57(11-12):990-3.
- 27. Leela NK, Vipin TM, Shafeekh KM, Priyanka V, Rema J. Chemical composition of essential oils from aerial parts of Cinnamomum malabatrum (Burman f.) Bercht & Presl. Flavour and fragrance journal. 2009 Jan;24(1):13-6.
- 28. Mallavarapu GR, Ramesh S, Chandrasekhara RS, Rajeswara Rao BR, Kaul PN, Bhattacharya AK. Investigation of the essential oil of cinnamon leaf grown at Bangalore and Hyderabad. Flavour and fragrance journal. 1995 Jul;10(4):239-42.
- 29. Illés V, Daood HG, Perneczki S, Szokonya L, Then M. Extraction of coriander seed oil by CO2 and propane at super-and subcritical conditions. The Journal of Supercritical Fluids. 2000 Apr 10;17(2):177-86.
- Wijesekera RO, Jayewardene AL, Rajapakse LS. Volatile constituents of leaf, stem and root oils of cinnamon (*Cinnamomum zeylanicum*). Journal

- of the Science of Food and Agriculture. 1974 Oct;25(10):1211-20.
- Isogai A, Suzuki A, Tamura S, Murakoshi S, Ohashi Y, Sasada Y. Structures of cinnzeylanine and cinnzeylanol, polyhydroxylated pentacyclic diterpenes from Cinnamonum zeylanicum Nees. Agricultural and Biological Chemistry. 1976 Nov 1;40(11):2305-6.
- Vernin G, Vernin C, Metzger J, Pujol L, Parkanyi C. GC/MS analysis of cinnamon and cassia essential oils: a comparative study. Developments in food science. 1994.
- 33. Muddgal D. Dravyagun Vijnana. Ayurvedic hindi pustak bhandar. 2nd edition 2019.
- 34. Sharma PV. Dravyagun Vigyan. Chaukambha Bharti Academy, Varanasi. 2019.
- 35. Gautam S, Gautam A, Chhetri S, Bhattarai U. Immunity against COVID-19: potential role of ayush kwath. Journal of Ayurveda and Integrative Medicine. 2020 Aug 17.
- Jakhetia V, Patel R, Khatri P, Pahuja N, Garg S, Pandey A, Sharma S. Cinnamon: a pharmacological review. Journal of advanced scientific research. 2010;1(2):19-23.
- 37. Wondrak GT, Villeneuve NF, Lamore SD, Bause AS, Jiang T, Zhang DD. The cinnamon-derived dietary factor cinnamic aldehyde activates the Nrf2-dependent antioxidant response in human epithelial colon cells. Molecules. 2010 May;15(5):3338-55.
- 38. Hossein N, Abolfazl M, Mahdi S, Ali K. Effect of Cinnamon zeylanicum essence and distillate on the clotting time. Journal of Medicinal Plants Research. 2013 May 17;7(19):1339-43.
- Singh S, Paul V, Singh R. Cinnamon Powder and its importance for immunity and human health. BMC Complement Altern Med.; 13:275Y284.
- 40. Chang ST, Chen PF, Chang SC. Antibacterial activity of leaf essential oils and their constituents from Cinnamomum osmophloeum. Journal of ethnopharmacology. 2001 Sep 1;77(1):123-7.
- 41. Hili P, Evans CS, Veness RG. Antimicrobial action of essential oils: the effect of dimethylsulphoxide on the activity of cinnamon oil. Letters in applied microbiology. 1997 Apr;24(4):269-75.

- 42. Matan N, Rimkeeree H, Mawson AJ, Chompreeda P, Haruthaithanasan V, Parker M. Antimicrobial activity of cinnamon and clove oils under modified atmosphere conditions. International journal of food microbiology. 2006 Mar 15;107(2):180-5.
- 43. Gende LB, Floris I, Fritz R, Eguaras MJ. Antimicrobial activity of cinnamon (*Cinnamomum zeylanicum*) essential oil and its main components against Paenibacillus larvae from Argentine. Bulletin of insectology. 2008 Jun;61(1):1.
- 44. Wang SY, Chen PF, Chang ST. Antifungal activities of essential oils and their constituents from indigenous cinnamon (Cinnamonum osmophloeum) leaves against wood decay fungi. Bioresource technology. 2005 May 1;96(7):813-8.
- 45. Mancini-Filho J, Van-Koiij A, Mancini DA, Cozzolino FF, Torres RP. Antioxidant activity of cinnamon (*Cinnamomum zeylanicum*, Breyne) extracts. Bollettino chimico farmaceutico. 1998 Dec 1;137(11):443-7.
- Shobana S, Naidu KA. Antioxidant activity of selected Indian spices. Prostaglandins, Leukotrienes and Essential Fatty Acids (PLEFA). 2000 Feb 1;62(2):107-10.
- 47. Mathew S, Abraham TE. Studies on the antioxidant activities of cinnamon (Cinnamomum verum) bark extracts, through various in vitro models. Food Chemistry. 2006 Mar 1;94(4):520-8.
- 48. Mathew S, Abraham TE. In vitro antioxidant activity and scavenging effects of Cinnamomum verum leaf extract assayed by different methodologies. Food and Chemical Toxicology. 2006 Feb 1;44(2):198-206.
- Kim NM, Sung HS, Kim WJ. Effect of solvents and some extraction conditions on antioxidant activity in cinnamon extracts. Korean Journal of Food Science and Technology. 1993;25(3):204-9.
- 50. Kim SH, Hyun SH, Choung SY. Anti-diabetic effect of cinnamon extract on blood glucose in db/db mice. Journal of ethnopharmacology. 2006 Mar 8;104(1-2):119-23.
- 51. Prabuseenivasan S, Jayakumar M, Ignacimuthu S. In vitro antibacterial activity of some plant essential oils. BMC complementary and alternative medicine. 2006 Dec;6(1):1-8.

- 52. Jia Q, Liu X, Wu X, Wang R, Hu X, Li Y, Huang C. Hypoglycemic activity of a polyphenolic oligomer-rich extract of Cinnamomum parthenoxylon bark in normal and streptozotocin-induced diabetic rats. Phytomedicine. 2009 Aug 1;16(8):744-50.
- 53. Jarvill-Taylor KJ, Anderson RA, Graves DJ. A hydroxychalcone derived from cinnamon functions as a mimetic for insulin in 3T3-L1 adipocytes. Journal of the American College of Nutrition. 2001 Aug 1;20(4):327-36.
- 54. Lu Z, Jia Q, Wang R, Wu X, Wu Y, Huang C, Li Y. Hypoglycemic activities of A-and B-type procyanidin oligomer-rich extracts from different Cinnamon barks. Phytomedicine. 2011 Feb 15;18(4):298-302.
- 55. Babu PS, Prabuseenivasan S, Ignacimuthu S. Cinnamaldehyde—a potential antidiabetic agent. Phytomedicine. 2007 Jan 10;14(1):15-22.
- 56. Tung YT, Yen PL, Lin CY, Chang ST. Antiinflammatory activities of essential oils and their constituents from different provenances of indigenous cinnamon (Cinnamomum osmophloeum) leaves. Pharmaceutical biology. 2010 Oct 1;48(10):1130-6.
- 57. Park IK, Park JY, Kim KH, Choi KS, Choi IH, Kim CS, Shin SC. Nematicidal activity of plant essential oils and components from garlic (Allium sativum) and cinnamon (Cinnamomum verum) oils against the pine wood nematode (Bursaphelenchus xylophilus). Nematology. 2005 Jan 1;7(5):767-74.
- 58. Kong JO, Lee SM, Moon YS, Lee SG, Ahn YJ. Nematicidal activity of cassia and cinnamon oil compounds and related compounds toward Bursaphelenchus xylophilus (Nematoda: Parasitaphelenchidae). Journal of nematology. 2007 Mar;39(1):31.
- 59. Cheng SS, Liu JY, Tsai KH, Chen WJ, Chang ST. Chemical composition and mosquito larvicidal activity of essential oils from leaves of different Cinnamomum osmophloeum provenances. Journal of agricultural and food chemistry. 2004 Jul 14;52(14):4395-400.
- Cheng SS, Liu JY, Huang CG, Hsui YR, Chen WJ, Chang ST. Insecticidal activities of leaf essential oils from Cinnamomum osmophloeum against three mosquito species. Bioresource Technology. 2009 Jan 1;100(1):457-64.

- 61. Lu J, Zhang K, Nam S, Anderson RA, Jove R, Wen W. Novel angiogenesis inhibitory activity in cinnamon extract blocks VEGFR2 kinase and downstream signaling. Carcinogenesis. 2010 Mar 1;31(3):481-8.
- 62. Aneja KR, Joshi R, Sharma C. Antimicrobial activity of Dalchini (*Cinnamomum zeylanicum* bark) extracts on some dental caries pathogens. J Pharm Res. 2009 Sep;2(9):1387-90.
- 63. Rao PV, Gan SH. Cinnamon: a multifaceted medicinal plant. Evidence-Based Complementary and Alternative Medicine. 2014 Oct;2014.
- 64. Singh N, Rao AS, Nandal A, Kumar S, Yadav SS, Ganaie SA, Narasimhan B. Phytochemical and pharmacological review of Cinnamomum verum J. Presl-a versatile spice used in food and nutrition. Food Chemistry. 2021 Feb 15; 338:127773.
- 65. Padnekar PA, Raman B. Pharmacognostic and phytochemical studies of Semecarpus anacardium (Linn.) F. Leaves. International Journal of Pharmacological and Pharmaceutical Science. 2012;4:682-685.
- 66. Amin S, Ghosh S, Biswas B, Arifuzzaman M, Azad MA, Siddiki AZ. Molecular identification of four medicinal plants using DNA barcoding approach from Chittagong, Bangladesh. Journal of Advanced Biotechnology and Experimental therapeutics. 2020;3(3):268-272.
- 67. Joharchi, M. R., & Amiri, M. S. Taxonomic evaluation of misidentification of crude herbal drugs marketed in Iran. Avicenna journal of phytomedicine. 2012;2(2):105.
- 68. Nithaniyal, S., Vassou, S. L., Poovitha, S., Raju, B., & Parani, M. Identification of species adulteration in traded medicinal plant raw drugs using DNA barcoding. Genome. 2017;60(2):139-146.
- 69. Raj, L. S., Vanila, D., & Ganthi, A. S. Comparative Pharmacognostical Studies on Genuine, Commercial and Adulterant Samples of Centella Asiatica (L.) Urban. Research & Reviews: A Journal of Pharmacology. 2013;3(2):6-9.
- 70. Rajeev K, Joshi VK, Vinod S, Suresh C, Chandra TR, Deep KG. Development of Herb Based Pharmaceutical Industry in Uttarakhand State. International Journal of Ayurveda and Pharma Research. 2015;3(3):1-7.

- Vijaya G. Assessment of pharmacognostic and phytochemical standards of Crataeva magna (Lour) DC stem and leaf. The Pharma Innovation Journal. 2018;7(4):892-898.
- 72. Vasconcelos NG, Croda J, Simionatto S. Antibacterial mechanisms of cinnamon and its constituents: A review. Microbial pathogenesis. 2018 Jul 1;120:198-203.
- Wisal GA. Antibacterial and antifungal effect of cinnamon. Microbiology Research Journal International. 2018 May 10:1-8.
- 74. Naveed R, Hussain I, Tawab A, Tariq M, Rahman M, Hameed S, Mahmood MS, Siddique AB, Iqbal M. Antimicrobial activity of the bioactive components of essential oils from Pakistani spices against Salmonella and other multi-drug resistant bacteria. BMC complementary and alternative medicine. 2013 Dec;13(1):1-0.
- 75. Abdalla RM, Abdelgadir AE. Antibacterial activity and phytochemical constituents of Cinnamomum verum and Matricaria chamomilla from Sudan. Bio Bulletin. 2016;2(2):01-0.
- 76. Mith H, Dure R, Delcenserie V, Zhiri A, Daube G, Clinquart A. Antimicrobial activities of commercial essential oils and their components against food-borne pathogens and food spoilage bacteria. Food science & nutrition. 2014 Jul;2(4):403-16.
- 77. Utchariyakiat I, Surassmo S, Jaturanpinyo M, Khuntayaporn P, Chomnawang MT. Efficacy of cinnamon bark oil and cinnamaldehyde on anti-multidrug resistant Pseudomonas aeruginosa and the synergistic effects in combination with other antimicrobial agents. BMC complementary and alternative medicine. 2016 Dec;16(1):1-7.
- 78. Saranya B, Sulfikarali T, Chindhu S, Muneeb AM, Leela NK, Zachariah TJ. Turmeric and cinnamon dominate in antioxidant potential among four major spices. Journal of Spices and Aromatic Crops. 2017 Jun 1;26(1):27-32.
- 79. Elgendy EM, Ibrahim HS, Elmeherry HF, Sedki AG, Mekhemer FU. Chemical and biological comparative in vitro studies of cinnamon bark and lemon peel essential oils. Food and Nutrition Sciences. 2016 Dec 9;8(1):110-25.
- 80. Beji RS, Khemir S, Wannes WA, Ayari K, Ksouri R. Antidiabetic, antihyperlipidemic and

- antioxidant influences of the spice cinnamon (*Cinnamomum zeylanicum*on) in experimental rats. Brazilian Journal of Pharmaceutical Sciences. 2018;54(2).
- 81. Durak A, Gawlik-Dziki U, Pecio Ł. Coffee with cinnamon–Impact of phytochemicals interactions on antioxidant and anti-inflammatory in vitro activity. Food chemistry. 2014 Nov 1;162:81-8.
- 82. Qabaha K, Abu-Lafi S, Al-Rimawi F. Antiinflammatory Activities of Ethanolic Extracts of curcuma Longa (Turmeric) and cinnamon (Cinnamomum verum).
- 83. Goyal M, Kaur H, Bhandari M, Rizvanov AA, Khaiboullina SF, Baranwal M. Antioxidant and Immune Effects of Water Soluble Polysaccharides Isolated from Cinnamomum verum Bark. BioNanoScience. 2018 Sep;8(3):935-40.
- 84. Mehrim AI, Salem MF. Medicinal herbs against aflatoxicosis in Nile tilapia (Oreochromis niloticus): Clinical signs, postmortem lesions and liver histopathological changes. Egy J aquac. 2013;3:13-25...
- 85. Bhagavathy S, Latha S. Anticarcinogenic effects of Cinnamomum verum on HL60 leukemia cell lines. Journal of Pharmacy Research. 2015 Dec;9(12):650-61.
- 86. Ezzat SK, AbuElkhair MT, Mourad MI, Helal ME, Grawish ME. Effects of aqueous cinnamon extract on chemically-induced carcinoma of hamster cheek pouch mucosa. Biochemistry and biophysics reports. 2017 Dec 1;12:72-8.
- 87. Shokri G, Fathi H, Jafari Sabet M, Nasri Nasrabadi N, Ataee R. Evaluation of anti-diabetic effects of hydroalcoholic extract of green tea and cinnamon on streptozotocin-induced diabetic rats. Pharmaceutical and Biomedical Research. 2015 Jun 10;1(2):20-9.
- 88. Sangi SM, Elwahab MF. Experimental evaluations of the nephroprotective properties of ginger (Zingiber officinale), Cinnamomum verum and Nigella sativa in STZ induced diabetic rats. International Journal of Biology, Pharmacy and Allied Sciences. 2017;6(6):1195-209.
- 89. El-Desoky GE, Aboul-Soud MA, Al-Numair KS. Antidiabetic and hypolipidemic effects of Ceylon cinnamon (Cinnamomum verum) in

- alloxan-diabetic rats. Journal of Medicinal Plants Research. 2012 Mar 9;6(9):1685-91.
- Li R, Liang T, Xu L, Li Y, Zhang S, Duan X. Protective effect of cinnamon polyphenols against STZ-diabetic mice fed high-sugar, highfat diet and its underlying mechanism. Food and Chemical Toxicology. 2013 Jan 1; 51:419-25.
- 91. Farahpour MR, Habibi M. Evaluation of the wound healing activity of an ethanolic extract of Ceylon cinnamon in mice. Vet Med. 2012 Jan 1;57(1):53-7.
- 92. Seyed Ahmadi SG, Farahpour MR, Hamishehkar H. Topical application of Cinnamon verum essential oil accelerates infected wound healing process by increasing tissue antioxidant capacity and keratin biosynthesis. The Kaohsiung journal of medical sciences. 2019 Nov;35(11):686-94.
- 93. Semenya SS, Potgieter MJ, Erasmus LJ. Ethnobotanical survey of medicinal plants used by Bapedi traditional healers to manage HIV/AIDS in the Limpopo Province, South Africa. Journal of Medicinal Plants Research. 2013 Feb 25;7(8):434-41.
- 94. Sohrabi R, Pazgoohan N, Seresht HR, Amin B. Repeated systemic administration of the cinnamon essential oil possesses anti-anxiety and anti-depressant activities in mice. Iranian journal of basic medical sciences. 2017 Jun;20(6):708.
- 95. Fadaei S, Asle-Rousta M. Anxiolytic and antidepressant effects of cinnamon (Cinnamomum verum) extract in rats receiving lead acetate. Scientific Journal of Kurdistan University of Medical Sciences. 2017;22(6).
- 96. Khasnavis S, Pahan K. Cinnamon treatment upregulates neuroprotective proteins Parkin and DJ-1 and protects dopaminergic neurons in a mouse model of Parkinson's disease. Journal of Neuroimmune Pharmacology. 2014 Sep;9(4):569-81.
- 97. Isaac-Renton M, Li MK, Parsons LM. Cinnamon spice and everything not nice: many features of intraoral allergy to cinnamic aldehyde. Dermatitis. 2015 May 1;26(3):116-21.
- 98. Cardoso-Ugarte GA, López-Malo A, Sosa-Morales ME. Cinnamon (*Cinnamomum zeylanicum*) essential oils. InEssential Oils in Food Preservation, Flavor and Safety 2016 Jan 1 (pp. 339-347). Academic Press.