# Unveiling the Medicinal and Ayurvedic Marvels and Mysteries of Cinnamon

Ghulam Murtaza[1], Muhammad Nadeem [2], Sundas Asghar*[3], Muhammad Mobashar [4], Razia Kauser[1], Hira karamat[5], Muhammad Usman[6], Aqsa Shafique[7], Muhammad Usama Ramzan[9], Bilal Ahmad Noor[10], Muhammad Adil[9]

1. Department of Anatomy, University of Agriculture Faisalabad, 38040, Pakistan.
2. Department of Parasitology, University of Agriculture Faisalabad, 38040, Pakistan.
3. Department of Zoology, The University of Lahore, Sargodha Campus, Pakistan.
4. Department of Animal Nutrition, The University of Agriculture Peshawar, Pakistan.
5. Chemistry department, University of Agriculture Faisalabad, 38040, Pakistan.
6. Department of Poultry Science, University of Agriculture Faisalabad, Sub Campus Toba Tek Singh, Punjab, Pakistan.
7. Chemistry department, Quaid-i-Azam University, Islamabad, Pakistan.
9. Department of Clinical Medicine & Surgery, University of Agriculture Faisalabad, 38040, Pakistan.
10. Faculty of Veterinary Science, University of Agriculture Faisalabad, 38040, Pakistan.

**Abstract-** Cinnamon is a perennial plant deeply rooted in the world of ethnopharmacology. It is one of the most ubiquitous spices revered globally. Its historical use as a traditional phytomedicine spans several centuries. Cinnamon is a medicinal plant with different compounds in its bark, leaves, fruits, and roots, like cinnamaldehyde, cinnamate, and cinnamic acid. Research on animals, in-vivo and in-vitro, showed that cinnamon has many health benefits as per Ayurveda and medical. These benefits include its ability to fight against various bacteria and fungi, and even some viruses. Similarly, It helps to reduce swelling and also works as an antioxidant. Cinnamon shows promising results in managing conditions like diabetes and cardiovascular health, and it also has effects as an antidepressant and even the potential to inhibit cancer progression. Additionally, its perceived efficacy as an analgesic underscores its multifaceted role in promoting human health. While this review comprehensively illuminates the medicinal and Ayurvedic attributes of cinnamon in both preclinical and clinical studies, its widespread utilisation in everyday life underscores its cultural and practical significance. Nevertheless, given the complex nature of its effects, this review highlights the imperative need for further research to establish comprehensive and conclusive recommendations regarding its optimal usage and potential therapeutic benefits.

**Keywords-** Cinnamon, Antibacterial, Antioxidant, Antidiabetic, Antiviral.

## I. INTRODUCTION

C Cinnamon comes from the bark of different trees in the Cinnamomum genus, belonging to the Lauraceae family, which has around 250 different types of plants. It is native to Sri Lanka and India, two-thirds are grown in Indonesia, and it is also cultivated in China, Burma, Vietnam, South America and the West Indies. There are four main species of commercially produced cinnamon, including *Cinnamomum verum* (*C. verum*), *Cinnamomum burmannii* (*C. burmannii*), *Cinnamomum cassia* (*C. cassia*), and *Cinnamomum loureiroi* (*C. loureiroi*). It is not only used as a spice for cooking but also encompasses applications in both traditional and contemporary medicine. These pharmacological properties of cinnamon include antibacterial (Gholamiveisi et al., 2023), antifungal (Özakar et al., 2023), antidiabetic (Mutlu et al., 2023), and antioxidant properties of cinnamon (Mutlu et al., 2023). Cinnamon has been employed as an anti-ulcer**,** anti-inflammatory (Ju et al., 2023), and anticancer agent (Banerjee and Banerjee, 2023). Cinnamon is generally utilized in the scent and essence sectors because of its fragrance and flavour, which may be used in a variety of foods, cosmetics,

and pharmaceuticals (Rao and Gan, 2014). The cinnamon plant contains different bioactive compounds and essential oils in its leaves, bark, and root, as shown (Błaszczyk et al., 2021).

Cinnamaldehyde and trans-cinnamaldehyde are the major compounds of cinnamon which are found in essential oil and contribute not only to its fragrance but also to the numerous biological effects associated with cinnamon (Błaszczyk et al., 2021). Research on *Cinnamomum osmophloeum* (*C. osmophloeum*) has proved that the cinnamon leaves essential oil encompasses a high concentration of trans-cinnamaldehyde. Therefore, *C. osmophloeum* is also used as a substitute spice for *C. cassia* in the spice industry (Ullah and Hassan, 2022).

Cinnamon (*C. zeylanicum*) is said to be one of the oldest medicinal plants. Cinnamon is a valuable spice enjoyed worldwide (Shivani and Chaudhary, 2020). E-cinnamaldehyde, found in the essential oil of *C. zeylanicum*, can counteract tyrosinase (Yu et al., 2022). Moreover, the antioxidants in cinnamon bark, called procyanidins, have different types known as A and B-type linkages (de Souza et al., 2021). People often use *C. cassia* in medicines because it has many therapeutic properties (Zaidi et al., 2015). The therapeutic roles of *C. cassia* include improved immunity and blood circulation along with its analgesic properties. Recent studies have also revealed that *C. cassia* treats oxidative stress, tumour formation, and mitochondrial dysfunction. In Alzheimer's disease, C. *cassia* plays a key role in preventing the aggregation of tau protein (Sharma et al., 2018). The significant component in the *C. cassia* extract is the cinnamaldehyde, which is described as an aromatic aldehyde and acts as an antipyretic agent by limiting the production of prostaglandin E2 and interleukin-1β (Das et al., 2022; Gunawardena et al., 2014).

**Methods:**

The current review was designed using an exhaustive and systematic search of the literature about various medicinal and health benefits of Spice cinnamon between 2010 and 2023. The explorations were performed using databanks, including Google Scholar (http://www.scholar.google.com/ (accessed on 18 October 2023), Science Direct (http://www.sciencedirect.com/ (accessed on 19 October 2023) Scirus (http://www.scirus.com/ (accessed on 20 October 2023) and PubMed (http://www.ncbi.nlm.nih.gov/pubmed (accessed on 21 October 2023). In our literature review, we concentrated on the latest research papers using the keywords: "cinnamon extract," "cinnamon's medicinal and Ayurvedic applications," "cinnamaldehyde," "bioactive compounds," and "medicinal properties of natural plants."

**Bioactive Compounds and Essential Oils in Different Parts of the Cinnamon Plant:**

The cinnamon plant contains different bioactive compounds and essential oils in its leaves, bark, and root. Cinnamyl acetate and coumarin are found in the fruit of cinnamon. Eugenol, cinnamaldehyde, and eucalyptol are predominantly found in the leaf oil, while trans-cinnamaldehyde, camphor, linalool, and benzoic acid, is the primary or fundamental compound present in the cinnamon bark or root bark oil as shown in Table 1 (Błaszczyk et al., 2021).

**Typical Applications**:

Cinnamon is very important as a spice but its essential oils and other components also have significant health benefits shown in Table 3. These benefits include the antibacterial (Gholamiveisi et al., 2023), antifungal (Özakar et al., 2023), antidiabetic (Mutlu et al., 2023), and antioxidant properties of cinnamon (Mutlu et al., 2023). Cinnamon has been employed as an anti-ulcer**,** anti-inflammatory (Ju et al., 2023), and anticancer agent (Banerjee and Banerjee, 2023). The risk of colon cancer can be decreased by cinnamon by enhancing colon health (Nile et al., 2023). Cinnamon acts as a coagulant to stop bleeding. Additionally, cinnamon promotes tissue regeneration and improves uterine blood circulation (Mahdavi Shahri, 2019). Cinnamon is a spice and flavouring ingredient that is also used to treat oral bacteria, bad breath, toothaches, and other dental issues (Nabavi et al., 2015).

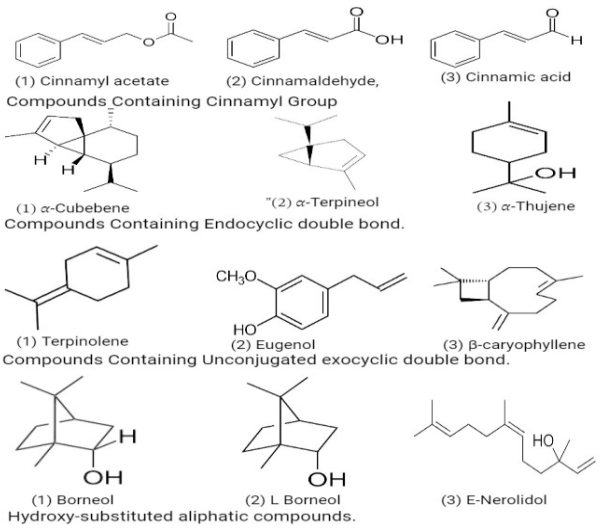
**Chemical Composition of Cinnamon:**

Cinnamon is comprised of numerous biologically active compounds including cinnamaldehyde, (E)-Cinnamyl acetate, Trans- $\alpha$- Bergamotene, Caryophyllene oxide, $\alpha$-Bergamotene, $\alpha$-Copaene, Trans-Cinnamyl acetate, cinnamic acid, cinnamate and several other essential oils that regulate its medical and Ayurvedic properties and have varying health effects (Table 2) (Hassan et al.,

2017). According to Hariri and Ghiasvand, cinnamaldehyde presents a fragrance and spicy taste due to the absorption of oxygen (Hariri and Ghiasvand, 2016). Researchers have reported the existence of a broad spectrum of essential oils, such as trans-cinnamaldehyde, eugenol, caryophyllene oxide, L-bornyl acetate, cinnamyl acetate, L-borneol, b-caryophyllene, E-nerolidol, $\alpha$-thujene, $\alpha$-cubebene, $\alpha$-terpineol, and terpinolene as shown in Figure 1 (Kowalska et al., 2021; Rao and Gan, 2014).

**Table 1: Chemical Components of Different Parts of cinnamon.**

**Figure 1: Cinnamon Compounds Containing Cinnamyl, Endocyclic Double Bond, Unconjugated Exocyclic Double Bond, Hydroxy-Substituted Aliphatic Compound.**




**Cinnamon's key Ayurvedic Medicinal Applications:**

Cinnamon is a helpful Ayurvedic phytomedicine plant for various health problems, as shown in Table 2. It is used as an expectorant and has anti-tubercular effects (Badnale et al., 2022; Thakur et al., 2021). Moreover, cinnamon is commonly used to treat sore throats, influenza, common colds, and headaches (Pathak and Sharma, 2021). Additionally, it helps to decrease cholesterol and strengthen the cardiac muscles (Shang et al., 2021). Its natural qualities make it an efficient rheumatoid arthritis therapy (Miraghajani and Ghiasvand, 2019) Furthermore, it can also aid in reducing menstrual discomfort. Recent research suggests that drinking warm cinnamon water regularly might temporarily alleviate menstrual pain (Irshad et al., 2022).

**Table 2: Ayurvedic Benefits of Health Promoting Cinnamon.**

| Compound | Parts of plant | Properties | References |
|---|---|---|---|
| (E)-Cinnamyl acetate | Flowers of *C. zeylanicum* | Pesticide, fragrance | (Ashfaq et al., 2021) |
| Trans- $\alpha$- Bergamotene | Flowers of *C. zeylanicum* | Medical properties and fragrance | (Adarsh et al., 2020) |
| Caryophyllene oxide | Flowers of *C. zeylanicum* | Medical properties insecticidal | (Apiaceae et al., 2011) |
| Terpene hydrocarbons | Buds of *C. zeylanicum* | Fragrances and flavouring agents | (Nair et al., 2022) |
| $\alpha$-Bergamotene | Buds of *C. zeylanicum* | Medical properties and fragrance | (Jayaprakasha and Rao, 2011) |
| $\alpha$-Copaene | Buds of *C. zeylanicum* | Natural fragrance and insect repellent | (Yassin et al., 2020) |
| Oxygenated terpenoids | Buds of *C. zeylanicum* | Anti-cancer properties. | (Tosya and Bolek, 2021) |
| Trans-Cinnamyl acetate | Fruits of cinnamon | Fragrance, Medical Properties | (Ribeiro-Santos et al., 2017) |
| Caryophyllene | Fruits of cinnamon | Anti-arthritic, anti-anxiety, and antidepressant. | (Zhang et al., 2019) |
| Cinnamaldehyde | Leaves of cinnamon<br>Barks of cinnamon | Anti-diabetic, anti-cancer, | (Ribeiro-Santos et al., 2017) |
| Eugenol | Leaves of cinnamon<br>Barks of cinnamon | Analgesic and is commonly used in dentistry. | (Nabavi et al., 2015). |
| Camphor | Root barks of cinnamon | Antiseptic, analgesic, used in vaporizers to aid cough suppression. | (Nabavi et al., 2015) |

| Health Benefits | Use | Recommended Method | References |
|---|---|---|---|
| Relieves Cough and Cold | Acts as an expectorant and expels mucus | Consume cinnamon stick soaked in warm water with honey and ginger juice multiple times a day | (Badnale et al., 2022) |
| Manages Diabetes | Regulates insulin production, reduces insulin resistance | Incorporate cinnamon supplements or a pinch of cinnamon in the diet regularly | (Shatwan et al., 2012) |
| Improves Digestion | Relieves flatulence, abdominal pain, and diarrhoea | Consume powdered bark with warm water and honey, or consume cinnamon tea daily | (Grogan, 2021) |
| Alleviates Cardiac Ailments | Acts as a natural blood thinner, reduces blood coagulation | Add a small bark of cinnamon to tea or food regularly | (Shang et al., 2021) |
| Enhances Skin Health | Fights acne, increases collagen production | Apply a paste of cinnamon powder and honey on affected areas, | (De Silva, 2020) |

| | | | |
|---|---|---|---|
| | | wash off after 10 minutes | |
| Remedies Arthritis | Reduces inflammation, offers pain relief | Apply cinnamon oil on affected areas or consume it regularly | (Vetal et al., 2013) (Miraghajani and Ghiasvand, 2019) |
| Uplifts Tooth And Gum Health | Prevents bad breath, tooth decay, and cavities | Try oil pulling with a drop of cinnamon oil in coconut oil or consume cinnamon tea regularly | (Nabavi et al., 2015). |
| Treats Candidiasis | prevents microbial infections like candida | Consume cinnamon tea to boost immunity or apply diluted cinnamon essential oil on affected areas for wound healing. | (Almeida et al., 2016; de Araújo et al., 2021) |

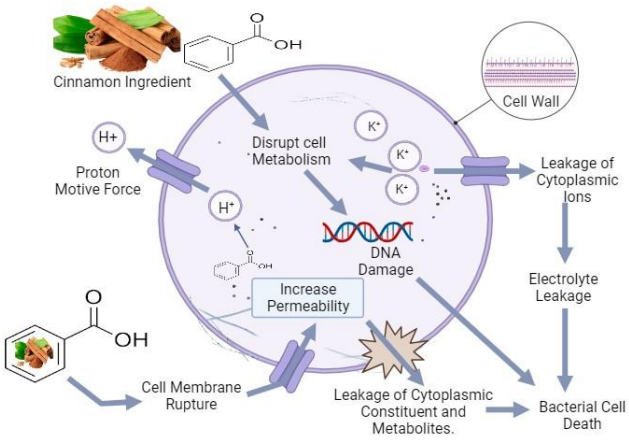
**Medical properties of cinnamon:**

**Antimicrobial properties:**

Cinnamon has been utilised in many studies and has shown significant antimicrobial properties. The antimicrobial activity of cinnamon was found to be more efficient when compared with commonly used antibiotics (El Atki et al., 2019). Cinnamaldehyde is the main component of cinnamon barks, widely known as "dar cheeni دار چینی", an aromatic aldehyde reported to have antibacterial activity against a variety of foodborne pathogens. Among the spoilage and foodborne pathogens, cinnamon essential oil has displayed antibacterial properties against various gram-positive bacteria (such as Bacillus species, *B. cereus, E. faecalis, Leuconostoc species, M. luteus, S. aureus, Streptococcus species, L. monocytogenes, L. grayi*) and gram-negative bacteria (including *E. coli, P. aeruginosa, P. fluorescens, S. dysenteriae, S. Typhimurium*) (Lucas-Gonzalez et al., 2023). (Goñi et al., 2009) described that the combined therapy of cinnamon and clove oils has been shown to have antibacterial properties against Gram-negative and Gram-positive bacteria (Goñi et al., 2009). A recent research highlighted the antibacterial mechanism of action of cinnamon and its components. They emphasized several effects observed when cinnamon or its constituents interact with bacteria, including changes in the cell membrane and its lipid composition, suppression of ATPase, cell division, membrane protein, motility, and the formation of biofilms as shown in Figure 2 (Vasconcelos et al., 2018). Therefore, understanding the antibacterial mechanism of these derived compounds will aid in the development of new antibacterial substances. The in-vitro antibacterial activity of cinnamon extract (cinnamaldehyde) has been evaluated previously against *Salmonella enterica* (Ebani et al., 2019). Cinnamon and its oils have been linked to several antibacterial effects, according to investigations conducted by (Nabavi et al., 2015; Vasconcelos et al., 2018). A previous study revealed the effectiveness of cinnamon and other plant extracts against oral microflora. Overall, the Cinnamon bark essential oil (CBEO) is more effective than examined plant extracts like *Syzygium aromaticum* and *Azadirachta indica* (Salam et al., 2015). (Wei et al., 2018) evaluated the cinnamaldehyde to check their antibacterial activity, against *B. subtilis* and *E. coli.* In previous studies, different concentrations of cinnamaldehyde have been utilized and the inhibition zone diameters for *E. coli* and *B. subtilis* were noted (Wei et al., 2018). After this study, (Wang et al., 2016) tested the effectiveness of these analogues in preventing the growth of *Staphylococcus aureus* (*S. aureus*) and *E. coli*. The findings showed that all these compounds inhibited the growth of *S. aureus* and *E. coli*, and the best antibacterial activity was shown against *E. coli*. When comparing the inhibition zone diameters, Wang found that the diameters of these analogues were much greater than that of cinnamon oil and that of ciprofloxacin. In the same study, Wang also tested two mould fungi and treated them with cinnamaldehyde analogues. The results showed more sensitivity of these fungi towards the cinnamaldehyde analogues when compared to the test bacteria: *S. aureus* and *E. coli (Wang et*

*al., 2016).* So, various derivatives of cinnamon can be used as natural antimicrobial agents against a variety of microorganisms in a cost-efficient manner. In recent studies, *Trans*-cinnamaldehyde has been used for further development of its various derivatives. Apart from the mechanism of action, many studies have been carried out to test the antibacterial properties of *trans*-cinnamaldehyde and its derivative compounds (Doyle and Stephens, 2019).

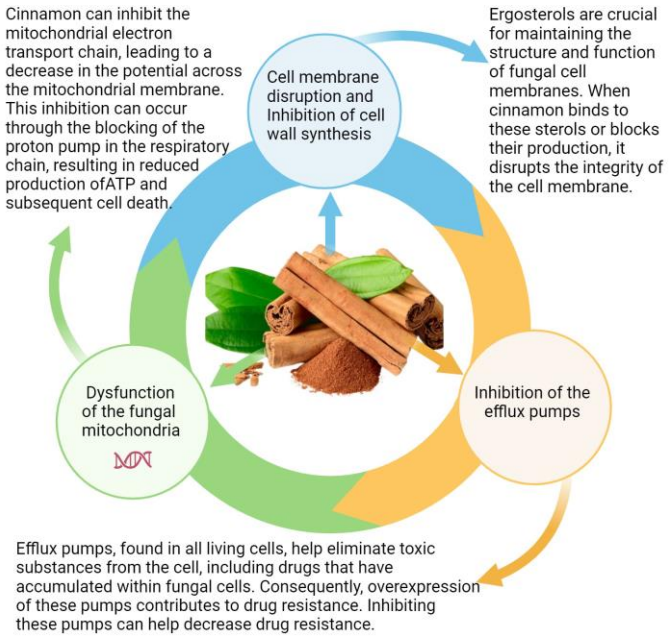
**Figure 2: Cinnamon Mechanism of Action as Antibacterial Agent.**




**Antifungal Properties:**

Cinnamon essential oil exhibits antifungal properties against various yeast and spoilage fungi, including *Aspergillus flavus, Mucor plumbeus, Penicillium expansum, Pediococcus halophilus Aspergillus niger, Mucor circinelloides, Penicillium chrysogenum, Penicillium roqueforti Penicillium citrinum, and Saccharomyces cerevisiae* (Doudi et al., 2016) (Lai et al., 2021). A study from (Hili et al., 1997) indicated that cinnamon oils have potential action against various yeast species, including *Pichia membranaefaciens, Saccharomyces cerevisiae Torulopsis utilize, Candida lipolytica, Debaryomyces hansenii, Candida albicans, Zygosaccharomyces rouxii*, and *Schizosaccharomyces pombe* (Hili et al., 1997). Its antifungal efficacy is often superior to other essential oils like garlic, oregano, rosemary clove, Carvacrol, ginger, and eucalyptus (Begum et al., 2022; Ebrahimzadeh et al., 2021; Radi et al., 2022). Furthermore, (Xie et al., 2017) investigated the relationship between the chemical structure of phenylpropene compounds in cinnamon essential oil and their antifungal effects. They found that the presence of a conjugated double bond, the length of the carbohydrate chain outside the ring, and the level of lipophilicity are critical determinants influencing the oil's antifungal properties (Xie et al., 2017). Cinnamon can inhibit fungal growth by various mechanisms, including cell membrane disruption, inhibition of cell wall synthesis, Dysfunction of the fungal mitochondria and Inhibition of the efflux pumps as shown in Figure 3.

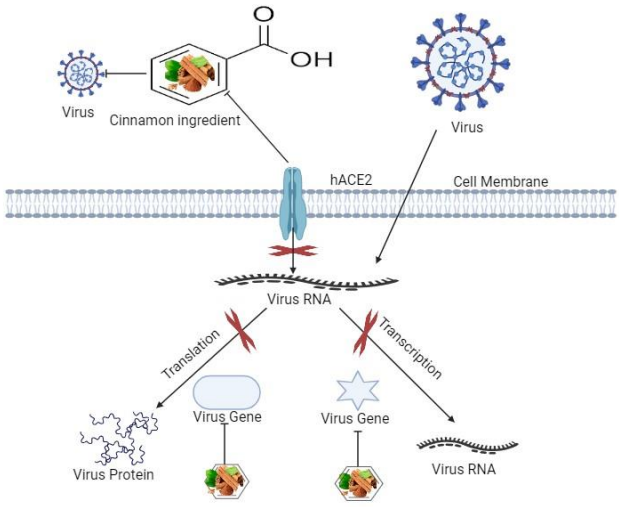
**Figure 3: Cinnamon Mechanism of Action as Antifungal Agent.**




**Antiviral Properties:**

Cinnamaldehyde produced from cinnamon bark inhibits the development of influenza A/PR/8 virus in vitro (Madin-Darby canine kidney cells) and in vivo (mice infected with the lung-adapted PR-8 virus (Hayashi et al., 2007). The bark extract of cinnamon (*C. cassia*) inhibits the virus-induced cytopathogenicity in HIV-infected MT-4 cells (Diksha et al., 2019). In vitro findings show that the bark oil of *C. cassia*, as well as aqueous and ethanolic extracts, exhibit significant antiviral activity against HI- and influenza virus (Akram et al., 2018). Although the two cinnamon species contain comparable components, these qualities have not been recorded for *C. zeylanicum*. More in vivo and in vitro study, in addition to human data, is required to prove cinnamon's antibacterial capabilities in free-living persons. Cinnamon can stop virus replication by inhibiting its transcription and translation process as shown in the figure in Figure 4 (Yakhchali et al., 2021).

**Figure 4: Cinnamon Mechanism of Action as Antiviral Agent.**




**Anti- Inflammation properties:**

Several researches on medicinal plants and their constituents have demonstrated that cinnamon has anti-inflammatory properties. CBEO from *the C. zeylanicum* tree has been relied used for centuries, in Ayurvedic medicine to relieve joint pain and reduce inflammation (Rani et al., 2023). In India, it's still used today for these purposes, likely because of its strong anti-inflammatory properties. CBEO was found to significantly lower the release of inflammatory cytokines and adhesion molecules, including those involved in tissue remodelling (Tanwar, 2019). It was seen to dramatically decrease a specific immune-controlling protein known as macrophage colony-stimulating factor. These discoveries suggest that CBEO can help reduce inflammation and potentially speed up the healing of wounds. Earlier studies have also hinted that both CBEO and its main active element, cinnamaldehyde, might be able to reduce inflammation (Chen et al., 2016; Mendes et al., 2016; Wang et al., 2015). To date, various flavonoid compounds including hesperidin, quercetin, gossiping, hypoplastic encephalin, and hibifolin have been identified and shown to have anti-inflammatory properties (Niranjani and Bhuvaneswari, 2022). A recent study revealed that *C. cassia* bark contains two hydroxy cinnamaldehyde, effectively inhibiting the production of nitric oxide by blocking the activation of the nuclear factor kappa-light-chain-enhancer of activated B cells (NF-$\kappa$B) (Banu and Lunghar, 2023). This finding suggests that the compound could serve as an anti-inflammatory agent. The *C. cassia* ethanolic extract demonstrated significant anti-inflammatory properties by decreasing the stimulation of Src/spleen-tyrosine-kinase- (Src/Syk-) mediated NF-$\kappa$B (Hariri and Ghiasvand, 2016). Certain compounds in *C. ramulus* can reduce inflammation in the central nervous system by controlling the production of specific enzymes and chemicals. They were seen to decrease the activity of certain enzymes like inducible nitric oxide synthase (iNOS) and cyclooxygenase-2 (COX-2), and they also reduce the production of nitric oxide (NO) (Rao and Gan, 2014). By using this mechanism, *C. ramulus* may be used for the treatment or prevention of neurodegenerative disorders caused by inflammation (Hariri and Ghiasvand, 2016).

**Antioxidant properties:**

Antioxidants are chemicals that interact with free radicals, slowing their oxidative process and protecting cells from damage. Antioxidant compounds present in natural foodstuffs maintain human health, which is essential to survival. Antioxidants are chemicals that interact with free radicals, slowing their oxidative process and protecting cells from damage. Antioxidant compounds present in natural foodstuffs maintain human health, which is essential to survival Besides this antioxidants are also one of the main additives in the food industry utilized in fats and oils to prevent deterioration (Gulcin, 2020). Cinnamon and medicinal herbs have quickly gained popularity as sources of advantageous antioxidants that can affect various diseases. Marta et al. demonstrated that cinnamon bark infusion exhibits potent antioxidant properties owing to the presence of polyphenols and volatile oil compounds (Marta et al., 2016). A simple extraction procedure may be used to create a high-antioxidant solution (Yashin et al., 2017). Cinnamon (*C. zeylanicum and C cassia*) is the highest potential source of antioxidants that are thought to be critical in addressing free radical reactions and minimizing damage in metabolic diseases and age-related illnesses in humans and animals (Rao and Gan, 2014).

Several cinnamon extracts contain biologically active compounds including trans-cinnamaldehyde, linalool, and eugenol. Abeysekera et al. confirmed that fully grown cinnamon leaves are very efficient in dealing with oxidative stress associated with chronic illnesses (Abeysekera et al., 2022). Cinnamaldehyde and its derivatives are the key components that contribute to natural therapeutic qualities. However, their study included two novel compounds: the lignan pinoresinol (PRO) and the flavonol (-)-(2R,3R)-5,7-dimethoxy-3',4'-methylenedioxy-flavan-3-ol (MFO), both of which have natural medicine applications by acting as oxidative stress inhibitors (Abeysekera et al., 2019; Li et al., 2019).

The ethanolic extract from *C. cassia* demonstrated notable inhibition (96.3%), surpassing the natural antioxidant $\alpha$-tocopherol (93.74%). In general, cinnamon displayed superior antioxidant properties in comparison to other commonly used spices (Abhay et al., 2021).

Cinnamon contains tannins, which are nonvolatile bioactive chemicals that have antioxidant effects and may have medicinal benefits. It includes both condensed tannins (proanthocyanidins) and hydrolyzable tannins both of which are known to be helpful (Ghosh, 2015). Tannins are known for their advantageous pharmacological effects, with their hydrolysis in a microbial environment leading to the generation of bioavailable metabolites responsible for systemic benefits (Sallam et al., 2021). The amount of tannins is commonly measured in percentages and varies according to the cinnamon species (Al-Numair et al., 2007). For example, the amount of tannins in *C. zeylanicum* was found to be 2.18% and 0.65%, measured in terms of catechins. In another study using LC-MS, it was discovered that *C. burmannii* extract has significant levels of condensed tannins, with 23.2% being proanthocyanidins and 3.6% being (epi)catechins (Shan et al., 2007). According to a rat study, using *C. verum* bark powder (10%) for 90 days resulted in antioxidant activities as shown by glutathione (Khanikar et al.), lipid conjugate dienes, and cardiac and hepatic antioxidant enzymes. According to a study, cinnamon oil may have superoxide-dismutase- (SOD-) like action as evidenced by the inhibition of pyrogallol autoxidation inhibition. Cinnamon's aqueous and alcoholic extract (1: 1) can greatly reduce lipid peroxidation and fatty acid oxidation in vitro (Dhuley, 1999).

**Anti-diabetic properties:**

Diabetes is highly prevalence and has become a significant public health concern. Due to the limitations of current glucose-lowering therapies, it is critical to explore and develop natural anti-diabetic alternatives (Sharma et al., 2020). Among the various varieties of cinnamon, *C. zeylanicum* is recognized for its efficacy as an alternative to diabetes (Ranasinghe et al., 2012). Cinnamaldehyde, constituting a significant component (65-80%) of the bark oil extracted from *C. zeylanicum*, demonstrates greater effectiveness in reducing plasma glucose levels in comparison to metformin. It enhances the expression of proteins linked to glucose transport and insulin signaling, while also regulating dyslipidemia. A molecule from cinnamon has been identified as "insulin-potentiating factor" (IPF) (Niranjani and Bhuvaneswari, 2022).

Cinnamon bark has been shown to have properties that can help with diabetes in rats induced with streptozotocin**.** (Hassan et al., 2012). Furthermore, Many studies have indicated that extracts from cinnamon can lower both cholesterol and blood sugar levels (Silva et al., 2022). In a research study, investigating the effects of different spices, the aqueous extract of cinnamon demonstrated an insulin-potentiating effect 20 times greater than that of the other spices (Rao and Gan, 2014). The pure hydroxychalcone polymer, also known as methylhydroxychalcone polymer (MHCP) can promote glucose oxidation (Senevirathne et al., 2022). Following this characterization, a novel substance called naphthalene methyl ester was created from hydroxycinnamic acid derivatives which have blood glucose-lowering effects, further confirming the anti-diabetic effects of cinnamon (Senevirathne et al., 2022).

**Antiplatelet and antithrombotic properties and cardiovascular properties:**

Studies have shown that cinnamaldehyde has properties that can prevent blood platelets from sticking together and forming clots. (Mehrpouri et al., 2020; Radice et al., 2017). Studies on anaesthetised rats have shown that it can also affect the heart and blood vessels by reducing blood pressure and relaxing the arteries. When the arteries were stimulated to contract, cinnamaldehyde helped to relax arteries (Yang et al., 2015). These studies suggest

that cinnamaldehyde shows cardiovascular effects as it carries out signals beyond the receptors. In the studies by (Xue et al., 2011) cinnamaldehyde was found to cause vasodilation in aorta rings that were isolated from rats (Xue et al., 2011). An active component of *C. cassia*, known as 2-methoxycinnamaldehyde (2-MCA), reduces the expression of vascular cell adhesion molecule-1 (VCAM1) in TNF$\alpha$-activated endothelial cells, suggesting a potential mitigation of ischemia/reperfusion (I/R) injury through the induction of hemeoxygenase (HO) 1 (Pandey et al., 2020). A recent study indicates that the two compounds derived from *C. cassia*, namely cinnamaldehyde and cinnamic acid, may possess protective properties against myocardial ischemia, highlighting cinnamon's potential in treating cardiovascular disorders (Das et al., 2022). Cinnamaldehyde has been shown to have beneficial effects on the cardiovascular system in various studies (Mohammed, 2020; Shang et al., 2021; Yang et al., 2015). Additionally, a notable significant lignan known as (Cinnamophilin) derived from *C. philippinensis*, has exhibited inhibition of the thromboxane A2 (TXA2) receptor in rats and guinea pigs (Nagaty, 2019). Cinnamophilin is considered a significant inhibitor of thromboxane synthase and a TXA2 receptor antagonist, and potentially beneficial in treating conditions associated with TXA2-related disorders, such as platelet aggregation and malignancies or cancer (Anand et al., 2016; Mollazadeh and Hosseinzadeh, 2016; Rao and Gan, 2014). Cinnamophilin could potentially help prevent vascular disorders and atherosclerosis by stopping the growth of vascular smooth muscle cells through the thromboxane receptor (Asgary et al., 2018; Rao and Gan, 2014). Cinnamaldehyde might widen blood vessels by blocking the entry and release of calcium. Along with its insulinotropic effects in insulin insufficiency, cinnamaldehyde delays the development of hypertension in people with types 1 and 2 diabetes by abridging vascular contractility (Nagaty, 2019)

**Analgesic and Antipyretic properties:**

*C. cassia* has been widely utilized in pharmaceutical preparations due to its various medicinal properties. The therapeutic roles of *C. cassia* include analgesic and antipyretic properties along with improving immunity and blood circulation (Hariri and Ghiasvand, 2016). Cinnamaldehyde is the main component in *C. cassia* extract. (Jardim et al., 2018). It helps reduce fever by stopping the body from making sure things like prostaglandin E2 and interleukin-1β. Scientists found that this happens because it affects some parts of the cells of mice that help in this process (Lu et al., 2022).

**Anticancer properties:**

In an in-vitro investigation, the water-soluble polysaccharide and different cinnamon extracts were tested for anticancer properties utilizing a cell proliferation assay on macrophage cell lines (Goyal et al., 2018). The study showed that a specific part of cinnamon helps the immune system more than other parts they tested. Also, the watery cinnamon extract could make mouth cancer grow slower, as they found out (Krauze et al., 2021).

**Wound healing properties:**

Cinnamon ethanolic extract has wound-healing effects in mice. The mice were administered 1.5 per cent or 3 per cent cinnamon extract for 14 days. The results demonstrated that 3 per cent of cinnamon extract has significant wound-healing capabilities (Pathak and Sharma, 2021).

**Antidepressant and antianxiety properties:**

Researchers have discovered that cinnamon essential oil can help with anxiety and depression (Sohrabi et al., 2017). They used tests like the forced swim test and the tail suspension test to check the antidepressant effects of Cinnamon essential oil (Sohrabi et al., 2017).

The elevated plus maze test (EPM) and the open field test were utilized by researchers to explore the CEO's anti-anxiety action (Han et al., 2018). In the FST test, Cinnamon significantly reduced the immobility time delay and extended the overall length of immobility whereas the EPM test showed a substantial reduction in entries into the open arms (Pathak and Sharma, 2021). As a result, these findings support that cinnamon extract possesses both anti-anxiety and anti-depressive effects.

**Table3: Cinnamon's Miscellaneous Health Benefits: A Comprehensive Overview of its Impact on Human Well-being.**

| Health Benefits | Plant Source | Compound | Mechanism of Action | References |
|---|---|---|---|---|
| Antimicrobial | Cinnamon | Cinnamaldehyde | Inhibits the growth of bacteria. | (Vasconcelos et al., 2018) |
| | Cinnamon | Cinnamaldehyde | Inhibit the growth of *S. aureus* and *E. coli*, and the best antibacterial activity was shown against *E. coli* | *(Wang et al., 2016).* |
| Antidiabetic | Cinnamon Extract | Polyphenols and Cinnamaldehyde | Enhances insulin sensitivity and reduces cholesterol synthesis, helping to lower blood sugar and cholesterol levels. | (Sivaranjani et al., 2021) |
| | *C. zeylanicum* | Cinnamaldehyde | Demonstrates greater effectiveness in reducing plasma glucose levels and also enhances the expression of proteins linked to glucose transport and insulin signalling | (Niranjani and Bhuvaneswari, 2022) |
| Antioxidant | Cinnamon | Cinnamaldehyde | Acts as an antioxidant, protecting the body from harmful substances. | (Ranasinghe et al., 2012) |
| | *C.zeylanicum and C cassia* | Cinnamaldehyde | Highest potential source of antioxidants that are thought to be critical in addressing free radical | (Rao and Gan, 2014) |

| | | | | |
|---|---|---|---|---|
| | | | reactions and minimizing damage in metabolic diseases and age-related illnesses in humans and animals | |
| Neuroprotective | Cinnamon Oil | Cinnamaldehyde | Enhances antioxidant defense mechanisms, reduces oxidative stress, and modulates gene expression to protect the brain from pesticide-induced damage. | (Ahmed et al., 2021) |
| | Cinnamomum species | Essential oils mainly cinnamaldehyde and sodium benzoate | Mainly protect against oxidative stress-induced cell death, reactive oxygen species generation, and autophagy dysregulation, thus acting in a potentially neuroprotective manner | (Angelopoulou et al., 2021) |
| Antiviral treatment | Cinnamon Extract | Polyphenols | Modulates immune responses, preventing excessive immune reactions in COVID-19. | (Yakhchali et al., 2021) |
| | *C. cassia* | Cinnamaldehyde | Inhibits the virus-induced cytopathogenicity in HIV-infected MT-4 cells. | (Diksha et al., 2019). |
| Anticancer | Cinnamaldehyde and Cinnamon Essential Oil | Cinnamaldehyde | Inhibits the proliferation of colon cancer cells and induces apoptosis, potentially suppressing colon cancer development. | (Kosari et al., 2020; Kumar et al., 2019) |
| | Cinnamon | Cinnamaldehyde | Interaction of its molecules in different pathways involved in the proliferation, survival, spread and programmed | (Alsayadi et al., 2022) |

| | | | | |
|---|---|---|---|---|
| | | | death of cells | |
| Lipid-lowering | Cinnamon Extract | Polyphenols | Inhibits enzymes involved in cholesterol synthesis, leading to a decrease in cholesterol and triglyceride levels in the body. | (Alsoodeeri et al., 2020) (El Sayed and Moustafa, 2016) |
| | Cinnamon | polyphenol | Decrease body weight, visceral fat, and lipid profile. | (Tuzcu et al., 2017) |

**Limitations:**

Cinnamon bark oil and cinnamaldehyde have irritating properties. It can irritate dosages larger than 0.2 grams per day which is equivalent to approximately 15-20 grams of crude drug (Pathak and Sharma, 2021). These findings were documented by the European Scientific Cooperative on Phototherapy in 2003 (ESCOP, 2003).

**Conclusion:**

Cinnamon, a well-known phytomedicine plant used in many Ayurvedic and medical systems worldwide, has various parts with different significant effects. Its bark, oils, and compounds have been well studied. Cinnamon, used as a spice for a long time, has not shown any adverse effects. Research has shown it can help with diabetes, inflammation, and maybe even cancer. It also prevents bacteria and harmful other microbes. Different types of cinnamon have been looked at for health benefits, but we need more research, especially for its traditional use against cancer and conditions like heart problems and brain issues, to have better proof from tests.

AUTHORS

**First Author** – Ghulam Murtaza, Department of Anatomy, University of Agriculture Faisalabad, 38040, Pakistan.
**Second Author** – Bilal Ahmad Noor, Faculty of Veterinary Science, University of Agriculture Faisalabad, 38040, Pakistan.
**Third Author** – Razia Kauser, Department of Anatomy, University of Agriculture Faisalabad, 38040, Pakistan.

**Correspondence Author** – Sundas Asghar,

**Reference:**

Abeysekera, W. P. K. M., Arachchige, S. P. G., Abeysekera, W. K. S. M., Ratnasooriya, W. D., Medawatta, H. M. U. I., (2019). Antioxidant and glycemic regulatory properties potential of different maturity stages of leaf of Ceylon Cinnamon (Cinnamomum zeylanicum Blume) in vitro. Evidence-Based Complementary and Alternative Medicine 2019.

Abeysekera, W. P. K. M., Premakumara, G. A. S., Ratnasooriya, W. D., Abeysekera, W. K. S. M., (2022). Anti-inflammatory, cytotoxicity and antilipidemic properties: Novel bioactivities of true cinnamon (Cinnamomum zeylanicum Blume) leaf. BMC Complementary Medicine and Therapies 22, 1-15.

Abhay, A. K., Rakesh, S. K., Nishant, K., Birendra, P., (Year) of Conference. Preparation of superfine cinnamon bark nanocrystalline powder using high energy ball mill and estimation of structural and antioxidant properties. In, 2021, p. 012020.

Abhay, A. K., Rakesh, S. K., Nishant, K., Birendra, P., (Year) of Conference. Preparation of superfine cinnamon bark nanocrystalline powder using high energy ball mill and estimation of structural and antioxidant properties. In, 2021, p. 012020.

Adarsh, A., Chettiyar, B., Kanthesh, B., Raghu, N., (2020).

Phytochemical screening and antimicrobial activity of "Cinnamon zeylanicum". Int. J. Pharm. Res. Innov 13, 22-33.

Ahmed, W. M. S., Abdel-Azeem, N. M., Ibrahim, M. A., Helmy, N. A., Radi, A. M., (2021). Neuromodulatory effect of cinnamon oil on behavioural disturbance, CYP1A1, iNOStranscripts and neurochemical alterations induced by deltamethrin in rat brain. Ecotoxicology and environmental safety 209, 111820.

Akram, M., Tahir, I. M., Shah, S. M. A., Mahmood, Z., Altaf, A., Ahmad, K., Munir, N., Daniyal, M., Nasir, S., Mehboob, H., (2018). Antiviral potential of medicinal plants against HIV, HSV, influenza, hepatitis, and coxsackievirus: A systematic review. Phytotherapy Research 32, 811-822.

Al-Numair, K. S., Ahmad, D., Ahmed, S. B., Al-Assaf, A. H., (2007). Nutritive value, levels of polyphenols and anti-nutritional factors in Sri Lankan cinnamon (Cinnamomum Zeyalnicum) and Chinese Cinnamon (Cinnamomum Cassia). Food Science & Agriculture Research Center, King Saud University 154, 5-21.

Almeida, L. d. F. D. d., Paula, J. F. d., Almeida, R. V. D. d., Williams, D. W., Hebling, J., Cavalcanti, Y. W., (2016). Efficacy of citronella and cinnamon essential oils on Candida albicans biofilms. Acta Odontologica Scandinavica 74, 393-398.

Alsayadi, A. I., Abutaha, N., Almutairi, B. O., Al-Mekhlafi, F. A., Wadaan, M. A., (2022). Evaluating the efficacy of an innovative herbal formulation (HF6) on different human cancer cell lines. Environmental Science and Pollution Research 29, 51768-51777.

Alsoodeeri, F. N., Alqabbani, H. M., Aldossari, N. M., (2020). Effects of cinnamon (Cinnamomum cassia) consumption on serum lipid profiles in albino rats. Journal of lipids 2020.

Anand, V., Kumar, S., Hedina, A., (2016). Cinnamomum zeylanicum Linn. The spice with multi potential. Systematic Reviews in Pharmacy 7.

Angelopoulou, E., Paudel, Y. N., Piperi, C., Mishra, A., (2021). Neuroprotective potential of cinnamon and its metabolites in Parkinson's disease: Mechanistic insights, limitations, and novel therapeutic opportunities. Journal of biochemical and molecular toxicology 35, e22720.

Apiaceae, A., Cupressaceae, G., Lamiaceae, L., (2011). Iranian plant essential oils as sources of natural insecticide agents. International Journal of Biological Chemistry 5, 266-290.

Asgary, S., Rastqar, A., Keshvari, M., (2018). Functional food and cardiovascular disease prevention and treatment: a review. Journal of the American College of Nutrition 37, 429-455.

Ashfaq, M. H., Siddique, A., Shahid, S., (2021). Antioxidant activity of cinnamon zeylanicum:(A review). Asian Journal of Pharmaceutical Research 11, 106-116.

Badnale, A. B., Sarukh, V. S., Nikam, Y. P., Supekar, A. V., Khandagale, S. S., (2022). A review on potential medicinal herbs as health promoters. Journal of Drug Delivery and Therapeutics 12, 225-229.

Banerjee, S., Banerjee, S., (2023). Anticancer potential and molecular mechanisms of cinnamaldehyde and its congeners present in the cinnamon plant. Physiologia 3, 173-207.

Banu, A. T., Lunghar, J., (2023). Cinnamon as a potential nutraceutical and functional food ingredient, In: Herbs, Spices and their Roles in Nutraceuticals and Functional Foods. Elsevier, pp. 257-278.

Begum, T., Follett, P. A., Mahmud, J., Moskovchenko, L., Salmieri, S., Allahdad, Z., Lacroix, M., (2022). Silver nanoparticles-essential oils combined treatments to enhance the antibacterial and antifungal properties against foodborne pathogens and spoilage microorganisms. Microbial pathogenesis 164, 105411.

Błaszczyk, N., Rosiak, A., Kałużna-Czaplińska, J., (2021). The potential role of cinnamon in human health. Forests 12, 648.

Chen, Y.-F., Wang, Y.-W., Huang, W.-S., Lee, M.-M., Wood, W. G., Leung, Y.-M., Tsai, H.-Y., (2016). Trans-

cinnamaldehyde, an essential oil in cinnamon powder, ameliorates cerebral ischemia-induced brain injury via inhibition of neuroinflammation through attenuation of iNOS, COX-2 expression and NFκ-B signaling pathway. Neuromolecular medicine 18, 322-333.

Das, G., Gonçalves, S., Heredia, J. B., Romano, A., Jiménez-Ortega, L. A., Gutiérrez-Grijalva, E. P., Shin, H. S., Patra, J. K., (2022). Cardiovascular protective effect of cinnamon and its major bioactive constituents: An update. Journal of Functional Foods, 105045.

de Araújo, M. R. C., Maciel, P. P., Castellano, L. R. C., Bonan, P. R. F., Alves, D. d. N., de Medeiros, A. C. D., de Castro, R. D., (2021). Efficacy of essential oil of cinnamon for the treatment of oral candidiasis: A randomized trial. Special Care in Dentistry 41, 349-357.

De Silva, T., (2020). Industrial applications of Ceylon cinnamon (Cinnamomum zeylanicum Blume) as nutraceuticals and cosmeceuticals. Cinnamon: Botany, Agronomy, Chemistry and Industrial Applications, 327-348.

de Souza, V. B., Holkem, A. T., Thomazini, M., Petta, T., Tulini, F. L., de Oliveira, C. A. F., Genovese, M. I., da Costa Rodrigues, C. E., Favaro Trindade, C. S., (2021). Study of extraction kinetics and characterization of proanthocyanidin-rich extract from Ceylon cinnamon (Cinnamomum zeylanicum). Journal of Food Processing and Preservation 45, e15429.

Dhuley, J. N., (1999). Anti-oxidant effects of cinnamon (Cinnamomum verum) bark and greater cardamom (Amomum subulatum) seeds in rats fed high fat diet.

Diksha, D., Upadhyay, S., Singh, S., Gururani, P., (2019). Enhancing the flavour of oil by Infusion of different herbs-review. The Pharma Innovation Journal 8, 626-632.

Doudi, M., Setorki, M., Rezayatmand, Z., (2016). Effects of aqueous extract of Cinnamomum verum on growth of bread spoilage fungi. International Journal of Medical Research & Health Sciences 5, 162-171.

Doyle, A. A., Stephens, J. C., (2019). A review of cinnamaldehyde and its derivatives as antibacterial agents. Fitoterapia 139, 104405.

Ebani, V. V., Nardoni, S., Bertelloni, F., Tosi, G., Massi, P., Pistelli, L., Mancianti, F., (2019). In vitro antimicrobial activity of essential oils against Salmonella enterica serotypes Enteritidis and Typhimurium strains isolated from poultry. Molecules 24, 900.

Ebrahimzadeh, S., Bari, M. R., Hamishehkar, H., Kafil, H. S., Lim, L.-T., (2021). Essential oils-loaded electrospun chitosan-poly (vinyl alcohol) nonwovens laminated on chitosan film as bilayer bioactive edible films. Lwt 144, 111217.

El Atki, Y., Aouam, I., El Kamari, F., Taroq, A., Nayme, K., Timinouni, M., Lyoussi, B., Abdellaoui, A., (2019). Antibacterial activity of cinnamon essential oils and their synergistic potential with antibiotics. Journal of advanced pharmaceutical technology & research 10, 63.

El Sayed, S. M., Moustafa, R. A., (2016). Effect of combined administration of ginger and cinnamon on high fat diet induced hyperlipidemia in rats. Journal of Pharmaceutical, Chemical and Biological Sciences 3, 561-572.

Gholamiveisi, M., Zinadini, S., Zinatizadeh, A. A., (2023). High-performance CPES nanofiltration membrane decorated by cinnamon extract with efficient antibacterial/anti-fouling property for post treatment of biologically treated industrial wastewater. Journal of Environmental Chemical Engineering 11, 110906.

Ghosh, D., (2015). Tannins from foods to combat diseases. Int J Pharm Res Rev 4, 40-44.

Goñi, P., López, P., Sánchez, C., Gómez-Lus, R., Becerril, R., Nerín, C., (2009). Antimicrobial activity in the vapour phase of a combination of cinnamon and clove essential oils. Food chemistry 116, 982-989.

Goyal, M., Kaur, H., Bhandari, M., Rizvanov, A. A.,

Khaiboullina, S. F., Baranwal, M., (2018). Antioxidant and immune effects of water soluble polysaccharides isolated from Cinnamomum verum bark. BioNanoScience 8, 935-940.

Grogan, B. B., (2021). Healing Spices Handbook. Union Square & Co.

Gulcin, İ., (2020). Antioxidants and antioxidant methods: An updated overview. Archives of toxicology 94, 651-715.

Gunawardena, D., Govindaraghavan, S., Münch, G., (2014). Anti-inflammatory properties of cinnamon polyphenols and their monomeric precursors, In: Polyphenols in human health and disease. Elsevier, pp. 409-425.

Han, C., Li, F., Tian, S., Liu, Y., Xiao, H., Wu, X., Zhang, W., Zhang, W., Mao, M., (2018). Beneficial effect of compound essential oil inhalation on central fatigue. BMC complementary and alternative medicine 18, 1-10.

Hariri, M., Ghiasvand, R., (2016). Cinnamon and chronic diseases. Drug discovery from mother nature, 1-24.

Hassan, S. A., Barthwal, R., Nair, M. S., Haque, S. S., (2012). Aqueous bark extract of cinnamomum zeylanicum: a potential therapeutic agent for streptozotocin-induced type 1 diabetes mellitus (T1DM) rats. Tropical Journal of Pharmaceutical Research 11, 429-435.

Hassan, S. M., Zulfiqar, S., Naeem, N., Ibrahim, A., Hassan, S. K., Majeed, A., Siddiqi, S. A., (2017). Cinnamon: A Multifunctional Medicinal Plant. Lahore Garrison University Journal of Life Sciences 1, 196-202.

Hayashi, K., Imanishi, N., Kashiwayama, Y., Kawano, A., Terasawa, K., Shimada, Y., Ochiai, H., (2007). Inhibitory effect of cinnamaldehyde, derived from Cinnamomi cortex, on the growth of influenza A/PR/8 virus in vitro and in vivo. Antiviral Research 74, 1-8.

Hili, P., Evans, C. S., Veness, R. G., (1997). Antimicrobial action of essential oils: the effect of dimethylsulphoxide on the activity of cinnamon oil. Letters in applied microbiology 24, 269-275.

Irshad, S., Aijaz, A., Husain, A., (2022). A Study of Menstruation and Stress: The Biological and Psychological Overview on Menarche and Menstrual Disorders. EPRA International Journal of Multidisciplinary Research (IJMR) 8, 85-90.

Jardim, I. N., Oliveira, D. F., Silva, G. H., Campos, V. P., de Souza, P. E., (2018). (E)-cinnamaldehyde from the essential oil of Cinnamomum cassia controls Meloidogyne incognita in soybean plants. Journal of Pest Science 91, 479-487.

Jayaprakasha, G. K., Rao, L. J. M., (2011). Chemistry, biogenesis, and biological activities of Cinnamomum zeylanicum. Critical reviews in food science and nutrition 51, 547-562.

Ju, J., Santana de Oliveira, M., Qiao, Y., (2023). The Application Potential of Cinnamon in Neuroprotection, In: Cinnamon: A Medicinal Plant and A Functional Food Systems. Springer, pp. 217-229.

Khanikar, D., Kataki, B., Tariang, A. D. J. B.-A. Q. J. o. L. S., (2023). Zoonoses: Current status and future prospects. 20, 22-27.

Kosari, F., Taheri, M., Moradi, A., Hakimi Alni, R., Alikhani, M. Y., (2020). Evaluation of cinnamon extract effects on clbB gene expression and biofilm formation in Escherichia coli strains isolated from colon cancer patients. BMC cancer 20, 1-8.

Kowalska, J., Tyburski, J., Matysiak, K., Jakubowska, M., Łukaszyk, J., Krzymińska, J., (2021). Cinnamon as a useful preventive substance for the care of human and plant health. Molecules 26, 5299.

Krauze, M., Cendrowska-Pinkosz, M., Matusevičius, P., Stępniowska, A., Jurczak, P., Ognik, K., (2021). The effect of administration of a phytobiotic containing cinnamon oil and citric acid on the metabolism, immunity, and growth performance of broiler chickens. Animals 11, 399.

Kumar, S., Kumari, R., Mishra, S., (2019). Pharmacological properties and their medicinal uses of Cinnamomum:

A review. Journal of Pharmacy and Pharmacology 71, 1735-1761.

Lai, T., Sun, Y., Liu, Y., Li, R., Chen, Y., Zhou, T., (2021). Cinnamon oil inhibits Penicillium expansum growth by disturbing the carbohydrate metabolic process. Journal of Fungi 7, 123.

Li, A.-L., Li, G.-H., Li, Y.-R., Wu, X.-Y., Ren, D.-M., Lou, H.-X., Wang, X.-N., Shen, T., (2019). Lignan and flavonoid support the prevention of cinnamon against oxidative stress related diseases. Phytomedicine 53, 143-153.

Lu, L., Xiong, Y., Zhou, J., Wang, G., Mi, B., Liu, G., (2022). The therapeutic roles of cinnamaldehyde against cardiovascular diseases. Oxidative Medicine and Cellular Longevity 2022.

Lucas-Gonzalez, R., Yilmaz, B., Khaneghah, A. M., Hano, C., Shariati, M. A., Bangar, S. P., Goksen, G., Dhama, K., Lorenzo, J. M., (2023). Cinnamon: An antimicrobial ingredient for active packaging. Food Packaging and Shelf Life 35, 101026.

Mahdavi Shahri, M., (2019). The antioxidant and anticoagulant effects of coumarin and quercetin from cinnamon methanolic extract, and the assessment of cinnamon powder effect on plasma parameters in diabetes, and the disinfectant activity in diabetic patients. Herbal Medicines Journal 4, 103-110.

Marta, E., Ye, N., Sy, E., (2016). Comparison of in vitro antioxidant activity of infusion, extract and fractions of Indonesian Cinnamon (Cinnamomum burmannii) bark. Comparison of in vitro antioxidant activity of infusion, extract and fractions of Indonesian Cinnamon (Cinnamomum burmannii) bark 23, 1346-1350.

Mehrpouri, M., Hamidpour, R., Hamidpour, M., Hamidpour, M., (2020). Cinnamon inhibits platelet function and improves cardiovascular system. Journal of Medicinal Plants 19, 1-11.

Mendes, S. J. F., Sousa, F. I. A. B., Pereira, D. M. S., Ferro, T. A. F., Pereira, I. C. P., Silva, B. L. R., Pinheiro, A. J., Mouchrek, A. Q. S., Monteiro-Neto, V., Costa, S. K. P., (2016). Cinnamaldehyde modulates LPS-induced systemic inflammatory response syndrome through TRPA1-dependent and independent mechanisms. International immunopharmacology 34, 60-70.

Miraghajani, M., Ghiasvand, R., (2019). Cinnamon and Arthritic Care, In: Bioactive Food as Dietary Interventions for Arthritis and Related Inflammatory Diseases. Elsevier, pp. 253-260.

Mohammed, M. T., (2020). Effects of Cinnamon and Their Beneficial Content on Treatment of Oxidative Stress. Systematic Reviews in Pharmacy 11.

Mollazadeh, H., Hosseinzadeh, H., (2016). Cinnamon effects on metabolic syndrome: a review based on its mechanisms. Iranian journal of basic medical sciences 19, 1258.

Mutlu, M., Bingol, Z., Uc, E. M., Köksal, E., Goren, A. C., Alwasel, S. H., Gulcin, İ., (2023). Comprehensive metabolite profiling of cinnamon (Cinnamomum zeylanicum) leaf oil using LC-HR/MS, GC/MS, and GC-FID: Determination of antiglaucoma, antioxidant, anticholinergic, and antidiabetic profiles. Life 13, 136.

Nabavi, S. F., Di Lorenzo, A., Izadi, M., Sobarzo-Sánchez, E., Daglia, M., Nabavi, S. M., (2015). Antibacterial effects of cinnamon: From farm to food, cosmetic and pharmaceutical industries. Nutrients 7, 7729-7748.

Nagaty, B. A., (2019). Evaluation of the potential protective effect of cinnamon extract against carbon tetrachloride-induced oxidative stress and hepatotoxicity in male albino rats.

Nair, A., Mallya, R., Suvarna, V., Khan, T. A., Momin, M., Omri, A., (2022). Nanoparticles—Attractive carriers of antimicrobial essential oils. Antibiotics 11, 108.

Nile, A., Shin, J., Shin, J., Park, G. S., Lee, S., Lee, J.-H., Lee, K.-W., Kim, B. G., Han, S. G., Saini, R. K., (2023). Cinnamaldehyde-Rich Cinnamon Extract Induces Cell Death in Colon Cancer Cell Lines HCT 116 and HT-29. International Journal of Molecular Sciences 24, 8191.

Niranjani, S., Bhuvaneswari, G., (2022). Exceptional health benefits of cinnamon. TNNMC Journal of Community Health Nursing 10, 42-46.

Özakar, E., Alparslan, L., Adıgüzel, M. C., Torkay, G., Baran, A., Bal-Öztürk, A., Sevinç-Özakar, R., (2023). A Comprehensive Study on Peppermint Oil and Cinnamon Oil as Nanoemulsion: Preparation, Stability, Cytotoxicity, Antimicrobial, Antifungal, and Antioxidant Activity. Current Drug Delivery.

Pandey, D. K., Chaudhary, R., Dey, A., Nandy, S., Banik, R. M., Malik, T., Dwivedi, P., (2020). Current knowledge of Cinnamomum species: a review on the bioactive components, pharmacological properties, analytical and biotechnological studies. Bioactive Natural products in Drug Discovery, 127-164.

Pathak, R., Sharma, H., (2021). A review on medicinal uses of Cinnamomum verum (Cinnamon). Journal of Drug Delivery and Therapeutics 11, 161-166.

Radi, M., Ahmadi, H., Amiri, S., (2022). Effect of cinnamon essential oil-loaded nanostructured lipid carriers (NLC) against Penicillium citrinum and Penicillium expansum involved in tangerine decay. Food and Bioprocess Technology 15, 306-318.

Radice, M., Silva, J., Correa, C., Moya, A., Escobar, J. A., Pérez, A., (Year) of Conference. Ocotea quixos essential oil: A systematic review about the ethno-medicinal uses, phytochemistry and biological activity. In, 2017.

Radice, M., Silva, J., Correa, C., Moya, A., Escobar, J. A., Pérez, A., (Year) of Conference. Ocotea quixos essential oil: A systematic review about the ethno-medicinal uses, phytochemistry and biological activity. In, 2017.

Ranasinghe, P., Jayawardana, R., Galappaththy, P., Constantine, G. R., de Vas Gunawardana, N., Katulanda, P., (2012). Efficacy and safety of 'true'cinnamon (Cinnamomum zeylanicum) as a pharmaceutical agent in diabetes: a systematic review and meta-analysis. Diabetic medicine 29, 1480-1492.

Rani, M., Jindal, S., Anand, R., Sharma, N., Ranjan, K. R., Mukherjee, M. D., Mishra, V., (2023). Plant Essential Oils and Their Constituents for Therapeutic Benefits. Essential Oils: Extraction Methods and Applications, 977-1008.

Rao, P. V., Gan, S. H., (2014). Cinnamon: a multifaceted medicinal plant. Evidence-Based Complementary and Alternative Medicine 2014.

Ribeiro-Santos, R., Andrade, M., Madella, D., Martinazzo, A. P., Moura, L. d. A. G., de Melo, N. R., Sanches-Silva, A., (2017). Revisiting an ancient spice with medicinal purposes: Cinnamon. Trends in Food Science & Technology 62, 154-169.

Salam, R., Sarker, B. K., Haq, M. R., Khokon, J. U., (2015). Antimicrobial activity of medicinal plant for oral health and hygiene. Int j nat soc sci 1, 1-12.

Sallam, I. E., Abdelwareth, A., Attia, H., Aziz, R. K., Homsi, M. N., von Bergen, M., Farag, M. A., (2021). Effect of gut microbiota biotransformation on dietary tannins and human health implications. Microorganisms 9, 965.

Senevirathne, B. S., Jayasinghe, M. A., Pavalakumar, D., Siriwardhana, C. G., (2022). Ceylon cinnamon: a versatile ingredient for futuristic diabetes management. Journal of future foods 2, 125-142.

Shan, B., Cai, Y.-Z., Brooks, J. D., Corke, H., (2007). Antibacterial properties and major bioactive components of cinnamon stick (Cinnamomum burmannii): activity against foodborne pathogenic bacteria. Journal of agricultural and food chemistry 55, 5484-5490.

Shang, C., Lin, H., Fang, X., Wang, Y., Jiang, Z., Qu, Y., Xiang, M., Shen, Z., Xin, L., Lu, Y., (2021). Beneficial effects of cinnamon and its extracts in the management of cardiovascular diseases and diabetes. Food & function 12, 12194-12220.

Sharma, H., Chauhan, P., Singh, S., (2018). Evaluation of the anti-arthritic activity of Cinnamomum cassia bark extract in experimental models. Integrative medicine

research 7, 366-373.

Sharma, S., Mandal, A., Kant, R., Jachak, S., Jagzape, M., (2020). Is cinnamon efficacious for glycaemic control in type-2 diabetes mellitus? Journal of the Pakistan Medical School 30, 32.

Shatwan, I. M. A., Ahmed, L. A., Badkook, M. M., (2012). Effect of Barley, Cinnamon and Their Combination on Type 2 Diabetic Rats.

Shivani, A. C., Chaudhary, P. A., (2020). Review on the use of Health Benefits of Cinnamon zeylanicum. International Medico-legal Reporter Journal 3, 124-127.

Silva, M. L., Bernardo, M. A., Singh, J., de Mesquita, M. F., (2022). Cinnamon as a complementary therapeutic approach for dysglycemia and dyslipidemia control in type 2 diabetes mellitus and its molecular mechanism of action: A review. Nutrients 14, 2773.

Sivaranjani, R., Zachariah, T. J., Leela, N. K., (2021). Phytotherapeutic potential of bi-herbal extract of cinnamon and turmeric: in vivo antidiabetic studies. Clinical Phytoscience 7, 1-9.

Sohrabi, R., Pazgoohan, N., Seresht, H. R., Amin, B., (2017). Repeated systemic administration of the cinnamon essential oil possesses anti-anxiety and anti-depressant activities in mice. Iranian journal of basic medical sciences 20, 708.

Tanwar, E., (2019). Assessment of Antibacterial, Anti-Inflammatory and Antioxidant Effects of Cinnamommum Zeylanicum (CINNAMON)–An In-Vitro Study.

Thakur, S., Walia, B., Chaudhary, G., (2021). Dalchini (cinnamomum zeylanicum): a versatile spice with significant therapeutic potential: Cinnamomum Zeylanicum. International Journal of Pharmaceutics and Drug Analysis 9, 126-136.

Tosya, F., Bolek, S., (2021). Effects of Cinnamon on Health and its Potential as a Functional Food Ingredient. Science of Spices & Culinary Herbs: Volume 5 5, 115-127.

Tuzcu, Z., Orhan, C., Sahin, N., Juturu, V., Sahin, K., (2017). Cinnamon polyphenol extract inhibits hyperlipidemia and inflammation by modulation of transcription factors in high-fat diet-fed rats. Oxidative medicine and cellular longevity 2017.

Ullah, M. A., Hassan, A., (2022). Cinnamon as Traditional and Modern Medicine. J Agri Horti Res 5, 141-150.

Vasconcelos, N. G., Croda, J., Simionatto, S., (2018). Antibacterial mechanisms of cinnamon and its constituents: A review. Microbial pathogenesis 120, 198-203.

Vetal, S., Bodhankar, S. L., Mohan, V., Thakurdesai, P. A., (2013). Anti-inflammatory and anti-arthritic activity of type-A procyanidine polyphenols from bark of Cinnamomum zeylanicum in rats. Food Science and Human Wellness 2, 59-67.

Wang, H., Yuan, H., Li, S., Li, Z., Jiang, M., (2016). Synthesis, antimicrobial activity of Schiff base compounds of cinnamaldehyde and amino acids. Bioorganic & medicinal chemistry letters 26, 809-813.

Wang, L., Hou, Y., Yi, D., Ding, B., Zhao, D., Wang, Z., Zhu, H., Liu, Y., Gong, J., Assaad, H., (2015). Beneficial roles of dietary oleum cinnamomi in alleviating intestinal injury. Frontiers in Bioscience-Landmark 20, 814-828.

Wei, Q., Wang, X., Cheng, J.-H., Zeng, G., Sun, D.-W., (2018). Synthesis and antimicrobial activities of novel sorbic and benzoic acid amide derivatives. Food chemistry 268, 220-232.

Xie, Y., Huang, Q., Wang, Z., Cao, H., Zhang, D., (2017). Structure-activity relationships of cinnamaldehyde and eugenol derivatives against plant pathogenic fungi. Industrial Crops and Products 97, 388-394.

Xue, Y.-L., Shi, H.-X., Murad, F., Bian, K., (2011). Vasodilatory effects of cinnamaldehyde and its mechanism of action in the rat aorta. Vascular health and risk management, 273-280.

Yakhchali, M., Taghipour, Z., Ardakani, M. M., Vaghasloo, M. A., Vazirian, M., Sadrai, S., (2021). Cinnamon and its possible impact on COVID-19: The viewpoint of

traditional and conventional medicine. Biomedicine & Pharmacotherapy 143, 112221.

Yang, L., Wu, Q.-Q., Liu, Y., Hu, Z.-F., Bian, Z.-Y., Tang, Q.-Z., (2015). Cinnamaldehyde attenuates pressure overload-induced cardiac hypertrophy. International journal of clinical and experimental pathology 8, 14345.

Yashin, A., Yashin, Y., Xia, X., Nemzer, B., (2017). Antioxidant activity of spices and their impact on human health: A review. Antioxidants 6, 70.

Yassin, M. T., Mostafa, A. A.-F., Al-Askar, A. A., (2020). Anticandidal efficiency of Cinnamomum zeylanicum extracts against vulvovaginal candidiasis. Curr. Sci 118, 796-801.

Yu, B., Wu, K., Duan, X., Zhang, T., He, D., Chai, X., (2022). Composition analysis and tyrosinase inhibitory activity of Cinnamomum cassia Presl leaf hydrosol and Cymbopogon citratus (DC.) Stapf leaf hydrosol. Journal of Food Processing and Preservation 46, e17058.

Zaidi, S. F., Aziz, M., Muhammad, J. S., Kadowaki, M., (2015). Diverse pharmacological properties of Cinnamomum cassia: A review. Pakistan journal of pharmaceutical sciences 28.

Zhang, C., Fan, L., Fan, S., Wang, J., Luo, T., Tang, Y., Chen, Z., Yu, L., (2019). Cinnamomum cassia Presl: A review of its traditional uses, phytochemistry, pharmacology and toxicology. Molecules 24, 3473.