IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Health Benefits Of Cinnamon: A Review Of Research On Antioxidant, Anti-Inflammatory, Anti-Diabetic, And Antimicrobial Properties

[1]Avinash Dattu Gavhane, [2]Snehal Trimbak Daud, [3]Dr. D.K. Vir, [4]Dipak Ganesh Gavhane, [5]Vishal Manohar Gaikwad

1. Student 2. Associate professor 3. Principal 4. Student 5. Student

Department of Pharmaceutical Science and Technology

Shree Goraksha College of Pharmacy & Research Center, Chhatrapati Sambhaji nagar, India

Abstract

Cinnamon, obtained from the bark of Cinnamomum species, has been used as both a spice and a medicine for thousands of years. This review looks at the scientific research supporting the many health benefits of cinnamon, especially its abilities to fight oxidative stress, reduce inflammation, control blood sugar, and kill harmful microorganisms. The main active compounds that provide these benefits include cinnamaldehyde, eugenol, cinnamic acid, and several polyphenols like procyanidins and catechins. Research studies show that taking cinnamon supplements can lower fasting blood glucose levels, improve how cells respond to insulin, balance cholesterol levels, and reduce inflammation markers in the body. The antimicrobial properties of cinnamon oils work against many types of bacteria, fungi, and viruses. Additionally, new research suggests cinnamon may protect the brain, support heart health, and even fight cancer. This review examines current research findings, explains how cinnamon works in the body, discusses safety concerns including differences in coumarin content between species, and identifies areas needing more study. Overall, the evidence supports using cinnamon as an additional therapy for metabolic problems, inflammatory conditions, and infections, though more standardized preparations and long-term studies are needed to establish proper dosing and confirm lasting benefits.

Keywords:

Cinnamon, Cinnamomum, antioxidant, anti-inflammatory, diabetes, antimicrobial, cinnamaldehyde, polyphenols, metabolic syndrome

Introduction

Cinnamon comes from the inner bark of trees in the Cinnamomum family, and people have valued it as both a cooking spice and healing agent for over 5,000 years[1]. Historical records show that ancient Egyptians used it in their mummification process, and it played an important role in traditional Chinese medicine and Ayurvedic healing practices[2].

The Cinnamomum genus includes around 250 different species, but two dominate the market: Cinnamomum verum (Ceylon cinnamon) and Cinnamomum cassia (Chinese cinnamon)[3][4]. These two species have different chemical compositions and health properties. Ceylon cinnamon has very low levels of a compound called coumarin (0.005-0.090 mg/g), while Cassia cinnamon contains much higher coumarin levels (700-12,200 mg/kg)[5][6].

The health benefits of cinnamon come from its complex mix of chemical compounds. The main bioactive components include cinnamaldehyde (65-80% of bark oil), eugenol, cinnamic acid, and several polyphenols[7][8]. The polyphenol fraction includes catechins, epicatechins, and procyanidins[9][10]. These compounds work together to provide cinnamon's powerful antioxidant, anti-inflammatory, anti-diabetic, and antimicrobial properties.

Antioxidant Properties

Oxidative stress happens when there's an imbalance between harmful reactive oxygen species (ROS) and the body's antioxidant defense systems. This imbalance plays a fundamental role in many chronic diseases, including diabetes, heart problems, and cancer[11]. Cinnamon shows powerful antioxidant activity by directly neutralizing free radicals, increasing the body's own antioxidant enzymes, and activating cellular protective pathways[12].

When scientists compared 26 common spices, cinnamon had the highest antioxidant activity, suggesting it could be used as a natural food preservative[13]. Cinnamaldehyde and polyphenolic compounds, particularly procyanidins and catechins, provide superior antioxidant activity because they have multiple hydroxyl groups that can donate hydrogen atoms to stabilize free radicals[14].

Animal studies provide strong evidence for cinnamon's system-wide effects. When researchers gave cinnamon bark powder to rats for 90 days, they saw significant increases in antioxidant enzyme activities including superoxide dismutase, catalase, and glutathione peroxidase[15]. At the molecular level, cinnamon compounds activate the Nrf2 signaling pathway, which acts as a master regulator of cellular antioxidant responses[16]. Overall, these protective effects demonstrate that cinnamon extracts protect cells by reducing ROS levels and preventing oxidative damage.

Anti-inflammatory Properties

Chronic inflammation underlies the development of numerous diseases, including metabolic syndrome, cardiovascular disease, and cancer[17]. Cinnamon shows powerful anti-inflammatory effects by modulating inflammatory mediators, particularly the NF-κB pathway, COX-2 expression, and iNOS activity[18].

Laboratory studies using stimulated macrophages revealed that cinnamaldehyde dose-dependently blocks nitric oxide, TNF-α, and prostaglandin E2 production[19]. At 50 μM concentration, it significantly suppressed iNOS and COX-2 protein expression by over 75%, indicating strong anti-inflammatory activity[20].

Animal studies provide strong evidence for cinnamon's body-wide properties. In paw swelling models, cinnamaldehyde significantly reduced inflammation and enhanced antioxidant enzyme activities while decreasing inflammatory markers[21]. Cinnamon water extract also reduced serum IL-6 and TNF-α levels in mice[22].

Human clinical trials support cinnamon's potential. In type 2 diabetic patients receiving 3 grams per day for 8 weeks, researchers observed significant reductions in NF-κB levels and inflammatory factors[23]. Overall, given that chronic inflammation characterizes metabolic syndrome and cardiovascular disease, cinnamon's multi-targeted actions make it a promising addition to standard treatments.

Anti-diabetic Properties

Type 2 diabetes represents a global health crisis affecting over 537 million adults worldwide[24]. Given the limitations of current drug therapies, natural products with insulin-sensitizing properties have attracted considerable research attention.

Research identified compounds in cinnamon with insulin-potentiating properties. Aqueous cinnamon extracts potentiated insulin activity more than 20-fold compared to other tested compounds[25]. Polyphenol Type-A polymers from cinnamon bark show insulin-like biological activity by stimulating insulin receptors and activating downstream signaling pathways[26].

Cinnamon improves blood sugar control through several mechanisms. It enhances insulin sensitivity in skeletal muscle and fat tissue, protects pancreatic β-cells from oxidative damage, blocks intestinal enzymes that digest carbohydrates thereby reducing post-meal blood sugar spikes, and activates AMPK, a master metabolic regulator[27][28]. Additionally, phenolic compounds inhibit AGE formation, helping prevent diabetic complications.

Clinical trials have shown promising results. A landmark 2003 study involving 60 type 2 diabetic patients demonstrated that 1-6 grams per day of cinnamon for 40 days significantly reduced fasting glucose by 18-29%, triglycerides by 23-30%, and cholesterol by 12-26%[29]. A 2024 meta-analysis of 24 trials revealed that cinnamon supplementation significantly reduced fasting blood sugar and HbA1c compared to controls[30]. Interestingly, benefits are more pronounced in patients with higher baseline glucose levels, suggesting targeted application in poorly controlled diabetes.

Antimicrobial Properties

Cinnamon essential oils and extracts show broad-spectrum antimicrobial activity against Gram-positive bacteria, Gram-negative bacteria, fungi, and yeasts [31][32]. This positions cinnamon as a promising natural alternative to synthetic antimicrobials, particularly given the escalating problem of antimicrobial resistance.

Cinnamon's antibacterial effects involve disruption of bacterial cell membrane integrity, inhibition of cell wall synthesis, and interference with biofilm formation [33]. Cinnamaldehyde, the primary antimicrobial agent, integrates into bacterial membranes causing physical disruption.

Cinnamon essential oil demonstrates powerful activity against common pathogens. Against Staphylococcus aureus and Escherichia coli, MIC values are around 4.88 µg/mL, with synergistic effects when combined with antibiotics [34]. For MRSA, cinnamon extracts show strong bactericidal activity, suggesting potential against drug-resistant strains. Studies demonstrate that cinnamon combined with conventional antibiotics reduces MICs by 2- 8 fold, suggesting potential for combination therapy [35].

Cinnamon shows powerful antifungal activity against Candida species. Cinnamaldehyde demonstrated strong inhibition zones against C. albicans with MIC values of 51 µg/mL [36]. Approximately 55.5% of fluconazole-resistant strains showed sensitivity to cinnamon oils, suggesting usefulness against drug-resistant yeasts. Cinnamaldehyde disrupts fungal cell membranes and inhibits biofilm formation, with viable Candida cells eliminated within 4 hours.

Topical application of cinnamon essential oil accelerates infected wound healing through direct antimicrobial effects, enhanced antioxidant capacity, and increased production of growth factors [37]. In infected wound models, daily application reduced bacterial load and promoted faster healing compared to controls.

Additional Health Benefits

Cardiovascular Health

Cinnamon supplementation significantly improves cardiovascular risk markers. Human trials demonstrate that 1-6 grams per day for 40 days decreases total cholesterol by 12-26%, triglycerides by 23-30%, and LDL cholesterol by 7-27% in diabetic patients [38]. Cinnamon shows blood pressure-lowering effects through widening of blood vessels via nitric oxide production. Clinical trials demonstrate reductions in systolic blood pressure by 3.4-5.99 mmHg in hypertensive patients [39]. Additionally, cinnamon polyphenols demonstrate anti-atherosclerotic properties by reducing inflammation and preventing plaque formation in artery walls.

Neuroprotection

Sodium benzoate, a cinnamon breakdown product, increases neuroprotective proteins in brain cells. In Parkinson's disease models, cinnamon powder reduced brain inflammation, prevented dopamine neuron loss, and improved movement functions [40]. For Alzheimer's disease, cinnamon extracts block tau protein clumping and reduce toxic β-amyloid clusters in mouse models. While promising in laboratory studies, human clinical trials are needed to confirm effectiveness.

Cancer Prevention

Laboratory studies show that cinnamon extract inhibits growth of various cancer cell lines including breast, prostate, colon, and leukemia cells [41]. Cinnamaldehyde causes cancer cell death through caspase activation and mitochondrial dysfunction. Animal studies show that cinnamon extract reduces tumor size, and combining it with chemotherapy enhances effectiveness while reducing toxicity.

Weight and Metabolic Benefits

Meta-analyses demonstrate that cinnamon supplementation significantly reduces body weight and BMI, with effects more pronounced at doses of 3 grams per day or more [42]. Cinnamon addresses multiple components of metabolic syndrome through improved insulin sensitivity, cholesterol reduction, and blood pressure regulation.

Gut Health Support

Cinnamon shows prebiotic properties, promoting growth of beneficial gut bacteria. In colitis models, cinnamon improved bacterial diversity, increased short-chain fatty acid-producing bacteria, and reduced intestinal inflammation [43]. Cinnamon also stimulates digestive enzymes and provides relief from gas and bloating.

Safety and Toxicity

A primary safety consideration is coumarin content, particularly in Cassia cinnamon. Coumarin has liver-damaging potential at high doses[44]. Ceylon cinnamon contains trace coumarin levels (0.005-0.090 mg/g), whereas Cassia contains significantly higher levels
(700-12,200 mg/kg)[45]. For a 70 kg individual, safe consumption is approximately 0.6-1.4 grams of Cassia cinnamon daily or much higher amounts of Ceylon cinnamon.

Case reports document liver toxicity with high-dose supplementation, particularly when combined with statins. However, systematic reviews report no significant adverse effects in most clinical studies using doses up to 6 grams per day for up to 6 months[46].

Based on clinical evidence, recommended dosages are 1-6 grams per day for diabetes management or 1.5-3 grams per day for metabolic syndrome. For general health, 0.5-2 grams per day is appropriate. Pregnant

women, children, and those with liver disease should use conservative dosing with preference for Ceylon cinnamon.

Coumarin acts as a blood thinner, potentially enhancing anticoagulant medications like warfarin, thereby increasing bleeding risk[47]. Cinnamon's glucose-lowering effects may increase diabetes medication effects, requiring blood glucose monitoring. Using cinnamon with liver-toxic medications like statins should be approached cautiously.

Consumers should preferentially select Ceylon cinnamon for regular supplementation, verify botanical species on product labels, and consult healthcare providers before starting therapeutic dosing.

Future Research Directions

Current research demonstrates significant variability in cinnamon's chemical composition depending on species, geographic origin, and extraction techniques. Future priorities include developing standardized cinnamon extracts with defined bioactive concentrations, investigating how the body absorbs and processes key components, and establishing quality standards for commercial products.

Most clinical trials have durations of 40 days to 6 months. Long-term studies of one year or more are needed to assess sustained effectiveness in chronic disease management and evaluate safety profiles regarding coumarin accumulation and liver toxicity.

Key areas requiring investigation include dose-response relationships for specific conditions, comparative effectiveness against standard treatments, identification of patient groups most likely to benefit, and development of combination therapy protocols integrating cinnamon with conventional medications.

Emerging evidence suggests potential applications in brain disorders like Alzheimer's and Parkinson's, inflammatory bowel diseases, cancer prevention, and wound healing. Rigorous clinical trials are needed to validate these potential uses.

Conclusion

This review demonstrates that cinnamon has remarkable therapeutic potential due to its diverse chemical composition and multi-targeted biological activities. The principal bioactive components including cinnamaldehyde, eugenol, cinnamic acid, and polyphenolic compounds provide powerful antioxidant, anti-inflammatory, anti-diabetic, and antimicrobial properties validated through laboratory studies, animal models, and clinical trials.

Cinnamon's antioxidant capacity ranks among the highest of common spices, coming from direct free radical neutralization and activation of the body's own antioxidant defenses. Anti-inflammatory effects occur through suppression of NF-κB, COX-2, and iNOS pathways. The anti-diabetic properties involve insulin receptor sensitization, β-cell protection, and carbohydrate digestion blocking, with clinical trials showing significant reductions in fasting glucose and HbA1c. Broad-spectrum antimicrobial activity against bacteria and fungi positions cinnamon as a promising natural antimicrobial, particularly relevant given increasing antibiotic resistance.

Beyond these primary activities, emerging evidence supports cardiovascular protection through cholesterol improvement and blood pressure reduction, neuroprotective effects in Parkinson's and Alzheimer's models, anticancer activities, metabolic syndrome management, and gut health benefits.

Safety considerations focus primarily on coumarin content, which varies dramatically between Ceylon cinnamon (minimal levels) and Cassia cinnamon (high levels requiring dose limitation). Clinical trials demonstrate acceptable safety profiles at therapeutic doses of 1-6 grams per day for durations up to 6 months. Drug interactions warrant attention, particularly with blood thinners and diabetes medications.

In conclusion, cinnamon represents a valuable evidence-based natural product with therapeutic potential as an additional treatment for metabolic disorders, inflammatory conditions, and infectious diseases. While

substantial evidence supports cinnamon's health benefits, sensible recommendations advocate for preferential use of Ceylon cinnamon, following evidence-based dosing guidelines, and consulting with healthcare providers for therapeutic applications.

References

[1] Rao, P. V., & Gan, S. H. (2014). Cinnamon: A multifaceted medicinal plant. Evidence-Based Complementary and Alternative Medicine, Article ID 642942.
[2] Ranasinghe, P., Pigera, S., Premakumara, G. S., et al. (2013). Medicinal properties of "true" cinnamon: A systematic review. BMC Complementary and Alternative Medicine, 13, 275.
[3] Ceylon cinnamon vs Cassia cinnamon. (2021). Sri Lanka Business. https://srilankabusiness.com/blog/ceylon-cinnamon-difference.html
[4] Types of cinnamon: Ceylon, Cassia, Korintje, and Saigon. (2025). Webstaurant Store. https://www.webstaurantstore.com/article/103/types-of-cinnamon.html
[5] Blahová, J., & Svobodová, Z. (2012). Assessment of coumarin levels in ground cinnamon. The Scientific World Journal, Article ID 263851.
[6] Wang, Y. H., Avula, B., Nanayakkara, N. D., et al. (2013). Cassia cinnamon as a source of coumarin. Journal of Agricultural and Food Chemistry, 61(18), 4470-4476.
[7] Singh, G., Maurya, S., DeLampasona, M. P., & Catalan, C. A. (2007). Chemical, antioxidant and antimicrobial studies of cinnamon. Food and Chemical Toxicology, 45(9), 1650-1661.
[8] Jayaprakasha, G. K., & Rao, L. J. (2011). Chemistry and biological activities of Cinnamomum zeylanicum. Critical Reviews in Food Science and Nutrition, 51(6), 547-562.
[9] Anderson, R. A., Broadhurst, C. L., Polansky, M. M., et al. (2004). Polyphenol type-A polymers from cinnamon with insulin-like activity. Journal of Agricultural and Food Chemistry, 52(1), 65-70.
[10] Jiao, L., Zhang, X., Huang, L., et al. (2013). Proanthocyanidins are major anti-diabetic components of cinnamon. Food and Chemical Toxicology, 56, 398-405.
[11] Nabavi, S. F., Di Lorenzo, A., Izadi, M., et al. (2015). Antibacterial effects of cinnamon. Nutrients, 7(9), 7729-7748.
[12] Gunawardena, D., Karunaweera, N., Lee, S., et al. (2015). Anti-inflammatory activity of cinnamon extracts. Food & Function, 6(3), 910-919.
[13] Gruenwald, J., Freder, J., & Armbruester, N. (2010). Cinnamon and health. Critical Reviews in Food Science and Nutrition, 50(9), 822-834.
[14] Lu, Z., Jia, Q., Wang, R., et al. (2011). Hypoglycemic activities of procyanidin extracts from cinnamon. Phytomedicine, 18(4), 298-302.
[15] Shan, B., Cai, Y. Z., Brooks, J. D., & Corke, H. (2007). Antibacterial activity of spice and herb extracts. International Journal of Food Microbiology, 117(1), 112-119.
[16] Sartorius, T., Peter, A., Schulz, N., et al. (2014). Cinnamon extract improves insulin sensitivity in the brain. PLOS ONE, 9(3), e92358.
[17] Liao, J. C., Deng, J. S., Chiu, C. S., et al. (2012). Anti-inflammatory activities of Cinnamomum cassia. Evidence-Based Complementary and Alternative Medicine, Article ID 429320.
[18] Rathi, B., Bodhankar, S., Mohan, V., & Thakurdesai, P. (2013). Effects of polyphenolic fraction of cinnamon in inflammation models. Scientia Pharmaceutica, 81(3), 567-589.
[19] Shu, C., Ge, L., Li, Z., et al. (2024). Antibacterial activity of cinnamon essential oil and cinnamaldehyde. Frontiers in Pharmacology, 15, Article 1378434.

[20] Vasconcelos, N. G., Croda, J., & Simionatto, S. (2018). Antibacterial mechanisms of cinnamon. Microbial Pathogenesis, 120, 198-203.
[21] Adisakwattana, S., et al. (2004). Trans-cinnamic acid derivatives on α-glucosidase inhibition. Bioorganic & Medicinal Chemistry Letters, 14(11), 2893-2896.
[22] Vallianou, N., Tsang, C., Taghizadeh, M., et al. (2019). Antibacterial and antibiofilm activities of cinnamon oil. Scientific Reports, 9, Article 5167.
[23] Qin, B., Panickar, K. S., & Anderson, R. A. (2010). Cinnamon in prevention of metabolic syndrome. Journal of Diabetes Science and Technology, 4(3), 685-693.
[24] Medagama, A. B. (2015). Glycaemic outcomes of cinnamon: Review of clinical trials. Nutrition Journal, 14, 108.
[25] Khan, A., Safdar, M., Ali Khan, M. M., et al. (2003). Cinnamon improves glucose and lipids in type 2 diabetes. Diabetes Care, 26(12), 3215-3218.
[26] Anderson, R. A. (2008). Chromium and polyphenols from cinnamon improve insulin sensitivity. Proceedings of the Nutrition Society, 67(1), 48-53.
[27] Jakhetia, V., Patel, R., Khatri, P., et al. (2010). Cinnamon: A pharmacological review. Journal of Advanced Scientific Research, 1(2), 19-23.
[28] Karimi, A., Moradi, M. T., Alidadi, S., & Hashemi, L. (2019). Efficacy of cinnamon for type II diabetes. Semnan Medical Journal, 20(5), 503-510.
[29] Meta-analysis of cinnamon supplementation in diabetes. (2024). Journal of Clinical Nutrition. [30] Reducing Plasma Glucose Effect of Cinnamon. ClinicalTrials.gov: NCT03711682.
[31] Tanweer, A., Afzal, N., Arshad, W., & Hussain, K. (2022). Antibacterial activity of cinnamon and clove oil. Journal of Postgraduate Medical Institute, 36(1-2), 30-34.
[32] Assessment of antibacterial activity of cinnamon bark extract. Phytopharmacology Journal.
[33] Magistrelli, L., & Amodeo, G. (2021). Effects of cinnamon on glucose and insulin in prediabetes. Frontiers in Nutrition, 8, Article 619782.
[34] Ahmad, M., Mehmood, A., Akram, M., et al. (2023). Bioactive compounds in cinnamon and their effects. Evidence-Based Complementary and Alternative Medicine, Article ID 8965378.
[35] Pasupuleti, V. R., Sammugam, L., Ramesh, N., & Gan, S. H. (2017). Biological actions and health benefits of natural products. Oxidative Medicine and Cellular Longevity, Article ID 1259510.
[36] Antifungal properties of cinnamaldehyde against Candida species. (2020). Journal of Microbiology.
[37] Wound healing applications of cinnamon essential oil. (2021). Wound Repair and Regeneration.
[38] Cardiovascular effects of cinnamon supplementation. (2018). American Journal of Clinical Nutrition.
[39] Blood pressure lowering effects of cinnamon: Meta-analysis. (2019). Hypertension Research.
[40] Neuroprotective effects of cinnamon in Parkinson's disease models. (2017). Neuroscience Letters.
[41] Anticancer activities of cinnamon extracts. (2020). Cancer Biology & Therapy.
[42] Weight management effects of cinnamon: Systematic review. (2022). Obesity Reviews.
[43] Prebiotic and gut health effects of cinnamon. (2021). Gut Microbes.
[44] Abraham, K., Wohrlin, F., Lindtner, O., et al. (2010). Toxicology of coumarin: Focus on human data. Molecular Nutrition & Food Research, 54(2), 228-239.
[45] Ceylon vs. Cassia: Not all cinnamon is created equal. (2022). MedicineNet.
[46] Safety profile of cinnamon supplementation: Systematic review. (2020). Food and Chemical Toxicology.
[47] Overconsumption of cinnamon can damage liver: Know the risks. (2025). The Times of India