Effects of Cinnamon in Dentistry

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Dental medicine is one of the fields of medicine where the most common pathologies are of bacterial and fungal origins. This review is mainly focused on the antimicrobial effects of cinnamon essential oil (EO), cinnamon extracts, and pure compounds against different oral pathogens and the oral biofilm and the possible effects on soft mouth tissue. Basic information is provided about cinnamon, as is a review of its antimicrobial properties against the most common microorganisms causing dental caries, endodontic and periodontal lesions, and candidiasis. Cinnamon EO, cinnamon extracts, and pure compounds show significant antimicrobial activities against oral pathogens and could be beneficial in caries and periodontal disease prevention, endodontics, and candidiasis treatment

Keywords: cinnamon essential oil ; dentistry ; oral pathogens ; oral biofilm ; candida ; antimicrobial effect ; dental caries ; endopathogens ; cinnamaldehyde ; eugenol

1. Introduction

Dental medicine is one of the fields of medicine where the most common pathologies are of bacterial and fungal origins. Widely spread diseases like dental caries, periodontal disease, and endodontic lesions are caused by well-known bacterial and fungal pathogens: *Streptococcus mutans, Streptococcus salivarius, Streptococcus sanguinis, Porfiromonas gingivalis, Prevotella intermedia, Actinobacilus actinomycetemcomitans, Enterococcus faecalis, Candida albicans,* etc. [1]. Preventive medicine relies mostly upon reducing the bacterial biofilm via oral hygiene. The most often used active ingredients in mouth rinses and toothpastes are chlorhexidine, hyaluronic acid, and fluorides. Although effective, chemical products may have some clinical disadvantages: teeth discoloration, taste alterations, mouth dryness, supragingival calculus accumulation, and oral mucosal lesions [2][3][4].

The attention of many researchers has focused on the antimicrobial properties of traditional medical substances, like essential oils (EOs) [5][6][7]. EOs and extracts have demonstrated effective antibacterial and antifungal properties [8][9][10][11]. In the field of dental medicine, oral hygiene products based on herbal extracts are well-known [12][13][14]. One of the substances most used by dental professionals is eugenol, which is an active component in root canal sealers, cements, and others. One of the EOs subjected to investigation in dentistry is cinnamon (*Cinnamomum* spp., Lauraceae family) [15].

2. Antimicrobial Effect of Cinnamon EO and Cinnamon Extracts Against Oral Pathogens

2.1. Antimicrobial Effect Against Caries Pathogens

Methanolic extract from *C. zeylanicum* produced inhibition zone diameters of 14.00 mm against *S. mutans* and 16.67 mm against *Lactobacillus acidophilus* [64]. The mean MIC (mg/mL) values were 13.44 against *S. mutans* and 5.18 against *L. acidophilus*. The mean MBC were 23.6 and 16.4 mg/mL, respectively. A combination of cinnamon and clove methanolic extracts resulted in larger inhibition zones. Ethanolic extract of *C. zeylanicum* showed good antimicrobial activity against *S. mutans* ATCC-700610: MIC = 195 µg/mL and MBC = 390 µg/mL [16].

Cinnamon EO showed the highest antibacterial activity against *S. mutans* among eight other EOs tested, including lime, spearmint, wintergreen, peppermint, lemongrass, cedarwood, clove, and eucalyptus EOs [17]. In a vast study investigating the antimicrobial properties of 32 EOs against oral pathogens, *S. mutans*, *Streptococcus sobrinus,* and *C. zeylanicum* EOs proved to be the most effective based on the inhibition zone measurements [18]. The antimicrobial effects of cinnamon against *S. mutans* and *Lactobacillus plantarum* proved to be stronger in comparison to tea tree, manuka, arnica, eucalyptus, and grapefruit [19]. In another study, the cinnamon EO did not prove its antibacterial properties against *S. mutans* [20]. The composition of the EO used in this study was mainly cinnamyl-alcohol (88.45%), cinnamyl-acetate (6.13%), and p-Eugenol (2.98%) One of the main antibacterial chemical compounds, cinnamaldehyde, was only responsible for 0.39% of the composition.

Data based on the MIC and MBC of cinnamon essential oil against caries pathogens are summarized in Table 1.

Table 1. Minimal inhibitory concentration (MIC) and minimal bactericidal concentration (MBC) of cinnamon EO and cinnamon extracts against cariogenic bacteria.

Cinnamon Species	EO or Extract	Bacterial Strains	MIC (%)	MBC (%)	Reference
C. zeylanicum	**EO**	***S. mutans*** ***L. casei***	**0.08** **0.16**	**0.08** **0.16**	[7]
C. zeylanicum	**Methanolic extract**	***S. mutans*** ***L. acidophilus***	**1.34** **0.52**	**2.36** **1.64**	[21]
C. zeylanicum	**Ethanolic extract**	***S. mutans***	**0.02**	**0.04**	[16]
C. zeylanicum	**Water extract**	***S. mutans***	**0.25**	**0.25**	[22]
C. zeylanicum	**EO**	***S. mutans***	**0.02–0.05**	**0.05–0.1**	[23]

2.2. Antifungal Activity of Cinnamon EO and Cinnamon Extracts

The combined effect of cinnamon, clove, and oregano obtained by hydrodistillation against several *C. albicans* strains, *Candida tropicalis* IP 2148.93, and *Candida glabatra* DSM 11226 was reported by Brochot A. et al. [24]. The MIC and the minimal fungicidal concentration (MFC) varied between 0.01% and 0.05% *v/v*.

The antifungal effects of the EO of *C. zeylanicum* leaves (eugenol content 68.96%) against several *Candida* spp., including reference strains and oral isolates of *C. albicans, C. tropicalis,* and *C. krusei,* showed a MIC from 62.5 to 1000 µg/mL and a MFC from 125 to 1000 µg/mL [25]. The MIC/MFC ratio was similar to that of nystatine. After exposure for 8 h, a significant reduction in the fungal growth was observed up to a concentration of 750 µg/mL. The suppression of biofilm formation at this concentration was also reported. Cinnamon EO was also able to reduce *Candida* spp. monospecies and multispecies in mature biofilm at 24 and 48 h. This concentration is safe to use, since no significant reduction in the viability of human peripheral blood mononuclear cells was observed with concentrations of up to 1000 µg/mL.

Another study [26] of the antifungal activity of *C. zeylanicum* leaf EO (eugenol content 82.30%) found that, at concentrations of 312.5 or 625.0 µg/mL, all 12 tested strains of *C. albicans* and *C. tropicalis* were inhibited. At the same concentrations, the authors observed a fungicidal effect of cinnamon EO against all 12 strains, except one (MFC was 312.5 or 625.0 µg/mL). The experimental mouth rinse, containing cinnamon EO at the MIC, used in this study did not significantly change the surface roughness or the Vickers microhardness of the heat-polymerized acrylic resin in contrast to the nystatine group. Even at low concentrations, *C. zeylanicum* EO has an inhibitory effect against *C. albicans*. The authors reported a MIC of 0.005% (0.05 µl/mL), an MFC of 0.01%, and a 90% reduction in bacterial biofilm at 0.039% [61]. A MIC <0.05 mg/mL for the methanolic extract of *C. zeylanicum* against *C. albicans* was reported in another study [27].

C. zeylanicum EO proved to be the most effective EO against 40 *C. albicans* isolates but to a lesser extent than the antifungal drugs and the mouthwashes [28]. A hydroalcoholic extract of *C. zeylanicum* was used to assess the antimycotic activity of cinnamon against fluconazole-resistant *C. albicans*. The MIC at a concentration of 15.62 µg/mL was reported [29]. The MIC and MFC at 65.5 µg/mL against *C. albicans* were reported by Cavalcanti et al. using *C. cassia* EO [30]. Khan et al. reported a MIC of 19.5 µg/mL and an MFC of 78 µg/mL against *C. albicans* ATCC-10231 [16].

2.3. Antimicrobial Effect Against Endopathogens

Some studies focused on the antibacterial and antifungal effects of cinnamon EO and extracts against certain endodontic pathogens. The main cause of endodontic infection is the presence of microorganisms isolated as planktonic cells or biofilms [31]. *Enterococcus faecalis* is the most prevalent bacterium found in unsuccessful root canal treatments; some studies focused on the root canal irrigant efficiency against *C. albicans* [32][33].

The antimicrobial effect of steam-distillated *C. zeylanicum* bark EO against *E. faecalis* ATCC 29212 was reported by Abbaszadegan et al. [34], with a MIC at 0.01 mg/mL and MBC at 0.1 mg/mL. Cinnamon EO and the triple antibiotic paste used in the study were able to eliminate planktonic *E. faecalis* after 4 and 24 h, while calcium hydroxide paste failed to do so. Cinnamon EO showed better biocompatibility with experimental fibroblast cells in comparison to the other two substances.

The MIC of *C. zeylanicum* exhibited against planktonic *E. faecalis* was 10%, with complete bacterial inhibition after 30 s [35]. In a biofilm susceptibility assay on a cellulose nitrate membrane, complete bacterial inhibition was achieved after 12 h, in contrast to the faster activity of 3% sodium hypochlorite (NaOCl) of 2 min. The effect of cinnamon EO as a root canal irrigant is weaker than 3% NaOCl but could lead to 80–85% intracanal bacterial reduction [36]. A 20% ethanolic extract of *C. zeylanicum* was found to be even more effective against *E. faecalis* ATCC 29212 compared to 3% NaOCl [37]. The significant antimicrobial effect of *C. cassia* EO was proved against *C. albicans* and *E. faecalis* (MIC was 0.56 mg/mL). A wider inhibition zone in comparison to chlorhexidine digluconate (0.12%) and 1% sodium hypochlorite solutions was also observed [38]. Khan et al. reported MIC and MBC against *E. faecalis* ATCC-29212 at 95.7 and 1560 µg /mL, respectively [16].

2.4. Other Studies Against Oral Pathogens

Cinnamon EO could be beneficial in halitosis treatment, since it reduced *Solobacterium moorei* biofilm formation, with MIC of 0.039% and MBC of 0.156% [39].

The antimicrobial effect of ethanolic extracts from *C. zeylanicum* and *Salvadora persica* against periodontal pathogens *P. gingivalis, Tannerella forsythia, Treponema denticola,* and *A. actinomycetemcomitans* was also studied. The results indicated the higher efficacy of cinnamon against all tested pathogens and the synergetic effect with antibiotics. The MIC ranged from 1.56 to 12.5 mg/mL and MBC from 6.25 to 75 mg/mL for different bacteria [40].

C. zeylanicum EO proved to be more effective in comparison to *C. zeylanicum* bark aqueous extract against *Staphylococcus auricularis, Acinetobacter lwoffii, C. albicans,* and *Micrococcus* species that were collected and isolated from volunteers' oral cavities. *C. zeylanicum* EO was more effective than *S. aromaticum* EO, inhibiting the growth of all bacterial isolates [41]. This also indicates the activity of the experimental toothpaste used in the study containing: 35.00% calcium carbonate, 1.50% sodium lauryl sulfate, 30.00% glycerin, 1.00% sodium alginate, 00.12% sodium benzoate, 00.30% sodium saccharine, 2.50% plant extract, and purified water q.s.

Cinnamon EO could be useful in antibiotic treatments due to the possible synergetic effect. The combination of *C. zeylanicum* EO with amikacin showed a significant synergetic effect against *Acinetobacter* species with reduction of the MIC of amikacin [99]. The possible use of cinnamon bark EO as a modifying agent in the treatment of antibiotic-resistant bacteria was reported in combination with piperacillin [42].

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