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Original Research Article

The Antimicrobial Inhibitory Effect of Ginger, Cinnamon and Pomegranate Extracts: in Vitro Study

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Abstract: ***Aim of the Study*:** To compare the inhibitory antimicrobial effect of ginger, cinnamon, pomegranate peel extracts against *Enterococcus faecalis. Streptococcus mutans, Staphylococcus aureus and Candida albicans*. ***Materials and Methods*:** Fresh ginger, cinnamon and pomegranate peel were freshly purchased and accordingly prepared for 15% ethanolic extracts, subjected to microbiological assays to determine zones of growth and/or inhibition against *Enterococcus faecalis, Streptococcus mutans, Staphylococcus aureus and Candida albicans*. ***Results*:** Statistically significant antimicrobial inhibitory potential of *Enterococcus faecalis, Streptococcus mutans, Staphylococcus aureus and Candida albicans* were observed between and within the different extracted materials and the positive and negative control groups (p=0.000). The antimicrobial inhibition zone was significantly exhibited in the cinnamon extract group compared to the ginger and pomegranate peel groups, especially against S*treptococcus mutans and Candida albicans*, compared to the other groups. While *staphylococcus aureus* demonstrated substantial inhibitory effect towards pomegranate and cinnamon, whereas *Enterococcus faecalis* showed similar inhibitory zones with cinnamon and pomegranate. ***Conclusion*:** Cinnamon, Ginger, and Pomegranate exhibited prominent antibacterial inhibitory effects that hold potential for preventive and therapeutic applications. Particularly, Cinnamon showed the most significant antimicrobial activity against *Streptococcus mutans* and exhibited an anti-candidal inhibitory effect. ***Clinical Significance*:** The clinical significance of the antimicrobial effects of ginger, cinnamon, and pomegranate lies in their potential as natural alternatives or adjuncts to conventional antimicrobial agents, especially in the face of rising antibiotic resistance.

Keywords: Cinnamon, Ginger, Oral Microorganisms, Pomegranate Peel Extract.

INTRODUCTION

Dental caries and periodontal diseases are infectious, progressive diseases that disrupt the normal interaction between the tooth surface and microbial biofilm. Once ignored, carious lesions can result in tooth cavity, dentin/pulp injury, and subsequent tooth loss [1].

Cariogenic microorganisms, especially *Streptococcus mutans (S. mutans),* play an essential role in the pathogenesis of dental caries. Other microbes such as *Lactobacillus* and *Enterococcus faecalis* (*E. faecalis*) species are also associated with dental caries and pulp necrosis [2]. *E. faecalis* is a microorganism commonly detected in asymptomatic, persistent endodontic infections, with capability to compete with other

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microorganisms, invade dentinal tubules, and resist nutritional deprivation. These bacteria synthesize large polysaccharides from sucrose and play an important role in the development of dental caries [3]. Moreover, following an injury or trauma to the mucosa, microorganisms such as *Staphylococcus aureus (S. aureus)* may enter the blood stream and cause infective endocarditis of the heart valves [4].

Researchers have recently become increasingly interested in medicinal plants to find new sources with natural alternatives such as herbs and spices that have been used since ancient times and have been testified to hold antibacterial and antifungal agents that have less side effects, better patient tolerance, cost effective and readily available; some common herbs such as cilantro, basil, ginger, turmeric, garlic, cinnamon, beetroot, pomegranate and others offer great health benefits by virtue of their powerful phytochemical and antioxidant properties [2-5].

Ginger (Zingiber officinale) plant has more than 1200 species in 53 genera. It has been used as a medication since ancient times. According to the Chinese Pharmacopoeia, the medicinal uses and indications of ginger include epigastric pain, vomiting, diarrhea, weak pulse, dyspnea, cough, and sputum production [6]. Additionally, ginger has proven to have antibacterial [7-10], antifungal/antimycotic [11, 12], anticancer [13], antioxidants, and other various medicinal values [14, 15].

While Cinnamon (*Cinnamomum zeylanicum)* exhibit various bio-regulatory activities such as antibacterial [16, 17], antifungal [18-21]. Furthermore, cinnamon has been proven to lessen the incidence of various pathological conditions including antidiabetic effect by reduction of fasting blood glucose, increasing circulating insulin levels [22], anti-obesity effect by decreasing the total cholesterol, triglycerides [23], and anti-aging treatment [24]. Furthermore, it affords significant protection against Alzheimer's disease [25]. Cinnamon produces essential oils, resinous compounds, Cinnamic acid, Cinnamaldehyde and Cinnamate. Essential oil such as eugenol, a material used widely in dentistry nowadays, traditionally has been used to treat dental pain and combat halitosis [26].

Pomegranate *(Punica granatum L.)* plants have been introduced as a natural medicine for prevention and treatment of inflammation and cancer [21, 22]. Pomegranate is a flavonoid-containing food complement that have shown anti-inflammatory [**Error! Bookmark not defined.**, **Error! Bookmark not defined.**]. Antimicrobial [21], antiviral [30], and anti-candidal [31], characteristics along with free radical scavenging ability, immune system activation, and antioxidant properties [32-34].

Pomegranate has been assessed in prevention and treatment of chronic periodontitis gingivitis, and stomatitis [35]. The bioactive compounds of pomegranate show effectiveness in reducing dental plaque and microorganisms [36]. Anthocyanin dyes, the most important phenolic compounds of pomegranate, have been shown to possess anti-inflammatory effects [26,27]. Additionally, polyphenols may protect the host against oxidative stress and pathologic conditions such as cancer, cardiovascular disease, in addition to its astringent, wound healing, and anti-inflammatory effects [35,37].

To the best of our knowledge no study to this date has been carried out to compare the antimicrobial potential of ginger, cinnamon, and pomegranate. Since *Enterococcus faecalis*, *Streptococcus mutans*, *Staphylococcus aureus* and *Candida albicans* are the most commonly encountered microorganisms in the oral cavity. As a consequence, the following research was undertaken to compare the inhibitory antimicrobial effects of ginger, cinnamon, and pomegranate peel extracts against *Enterococcus faecalis*, *Streptococcus mutans*, *Staphylococcus aureus* and *Candida albicans.*

MATERIALS AND METHODS

The following research was undertaken after the approval of the College of Dentistry Research Centre and Deanship of Scientific Research at King Saud University, Riyadh, Saudi Arabia and registered under (CDRC # FR 0682).

Materials

Fresh ginger, cinnamon, and pomegranate peel extracts were freshly purchased from the local market and accordingly prepared and subjected to microbiological assays to determine zones of growth and/or inhibition against oral *Enterococcus faecalis, Streptococcus mutans, Staphylococcus aureus and Candida albicans (C. albicans).*

The standard strains of microorganisms purchased and used are as follows; *E. faecalis* (ATCC No. 29212), *S. mutans* (American Type Culture Collection-ATCC No. 25175), *S. aureus* (ATC No. 25923), *C. albicans* (ATC No. 60193).

Study Design

The study materials were grouped as follows:
Group 1: Pomegranate peel extract group
Group 2: Ginger group
Group 3: Cinnamon group
Group 4: Positive Control group (0.2% Chlorhexidine)
Group 5: Negative control group (0.9% Saline)
Each of these materials were subjected to the four different types of microorganisms and were tested in quadruplet.

METHODOLOGY

Preparation of Ethanolic Extracts

Fresh ginger, cinnamon, and pomegranate (500 grams each) were purchased from the local market and

cleaned using distilled water, minced into fine pieces, and accordingly prepared for ethanolic extracts and suspended in sterile jars containing 1000ml of 70 - 90 % ethanol each. They were subjected to the process of cold maceration for 48 hours in a sterile jar after which the process of filtration using sterile muslin cloth was carried out. The filtrates obtained were placed over steam bath apparatus for 5 days to facilitate evaporation of the ethanol content to acquire ginger, cinnamon and pomegranate peel extracts.

Preparation of 15% Ethanolic Extracts

For the preparation of 15% stock solution of ethanolic extracts, 15 grams from the acquired extracts were dissolved in 100ml of dimethyl sulfoxide to obtain 15% ethanolic extracts of ginger, cinnamon, and pomegranate respectively.

Determination of Zone of Inhibition (ZOI)

The stock solution of 15% ethanolic prepared extracts were subjected to agar disk diffusion test along with 0.2% chlorhexidine (CHX) as positive control and 0.9 % normal saline as negative control to determine the zone of inhibition against *E. faecalis, S. mutans*, *S. aureus and C. albicans* respectively. Interpretation of diffusion results were carried out by the presence or absence of zone of inhibition.

Antimicrobial Study

An agar diffusion test was utilized to measure the inhibition zone of the microbial growth for ginger, cinnamon, and pomegranate peel versus 0.2 % chlorhexidine as positive control and 0.9% normal saline as negative control. 80 sterile petri plates were divided over the five groups to be tested, 4 samples per group. The *E. faecalis*, *S. mutans, S. aureus and C. albicans* biofilms were spread on brain heart infusion (BHI) using a sterile swab and incubated at 37°C for 24 h, after incubation, new sterile petri disks were immersed separately in each of the tested material groups. Afterwards, they were mounted over the center of the agar plate and were measured after 48 h and the microbial growth and/ or inhibition zones were evaluated. The diameters of the inhibition zones were measured in millimeters (mm) for each sample. All the experimental procedures were carried out by one examiner under aseptic conditions.

Power of Sample

All the experimental investigations for all the plant extract and control groups with each microorganism was repeated 4 times as part of the laboratory standard confirmation protocol for reliability and accuracy. Henceforth, for α 0.05 with effect size 0.5 and power of 0.825, the total sample size should not have been less than 80, with not less than 16 in each group.

Statistical Analysis

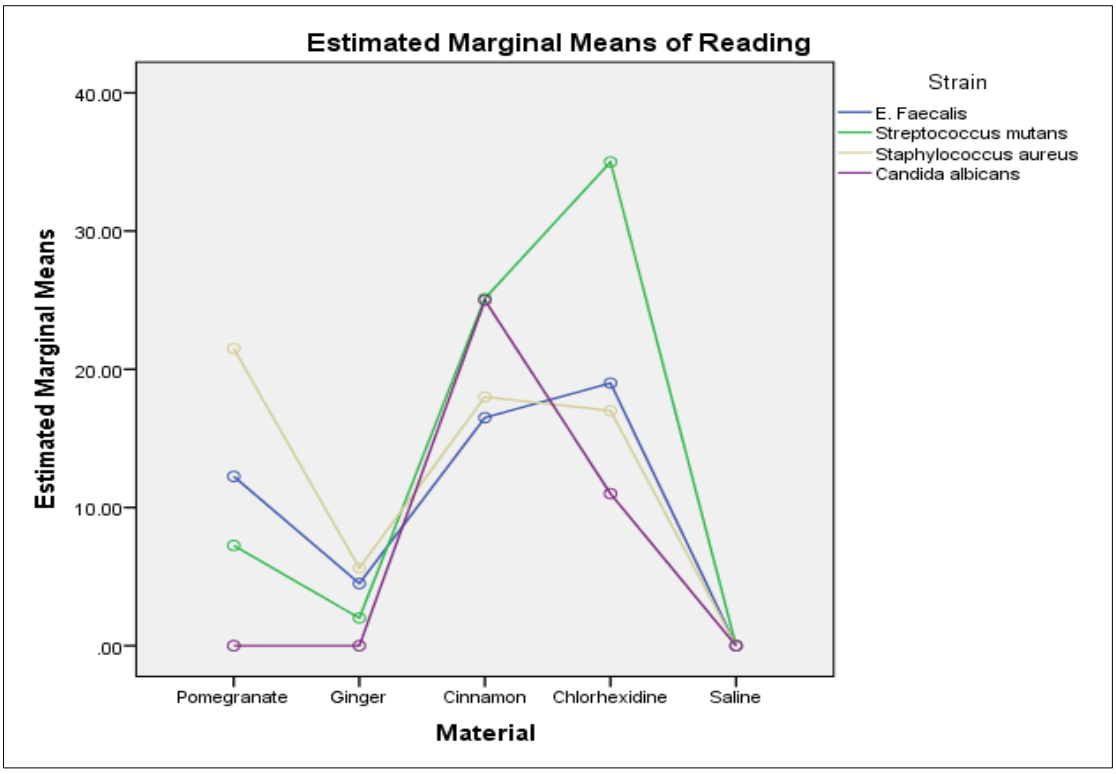
Descriptive statistical data analysis was performed using Statistical Package for the Social Sciences (SPSS) software version 26.0 (IBM Inc. Chicago, Illinois, USA). Mean, standard deviation, correlation between variables and One-way ANOVA and F-test were used. Additionally, for multiple comparison test (MCT), Dunnett's T3 and Tukey test was used for simultaneously comparing, by interval estimation or hypothesis to compare the antimicrobial potential of ginger, cinnamon and pomegranate extracts versus chlorhexidine and saline against *E. faecalis*, *S. mutans, S. aureus and C. albicans*. The significance level for all the statistical tests utilized in this study was set at $p < 0.05$.

RESULTS

The overall inhibitory effect of ginger, cinnamon, and pomegranate peel extracts along with the positive and negative control *against E. faecalis, S. mutans, S. aureus and C. albicans* are presented in Table 1 and Graph 1.

Table 1: Overall inhibitory effect of ginger, cinnamon, and pomegranate *against E. faecalis, S. mutans, S. aureus and C. albicans*

Extracted Plants	Microbial Strain			
	E. faecalis	*S. mutans*	S. *aureus*	*Candida albicans*
Ginger	✓	✓	✓	✗
Cinnamon	✓	✓	✓	✓
Pomegranate	✓	✓	✓	✗
0.2% Chlorhexidine	✓	✓	✓	✓
Saline	✗	✗	✗	✗



Graph 1: The inhibitory potential of *E. faecalis, S. mutans, S. aureus and C. albicans between* pomegranate, ginger, cinnamon extracts vs positive and negative control groups

Statistically significant antimicrobial inhibitory effects were observed between and within the different extracted materials (p=0.000) as shown in Table 2.

Statistically significant antimicrobial inhibitory potential of *E. faecalis, S. mutans, S. aureus and C. albicans* were observed between the different extracted materials and the positive and negative control group (p=0.000) as shown in Table 2.

Table 2: The antimicrobial inhibitory potential of *E. faecalis, S. mutans, S. aureus and C. albicans* between pomegranate, ginger, cinnamon extracts vs positive and negative control groups

Strain	Materials	N	Mean	Std. Deviation	*P*-value	95% Confidence Interval for Mean		MCT
						Lower Bound	Upper Bound	
E. Faecalis	**Pomegranate**	4	12.250	4.573	**0.000***	4.973	19.527	**bc**
	Ginger	4	4.500	9.000		-9.821	18.821	**ab**
	Cinnamon	4	16.500	3.873		10.337	22.663	**c**
	Chlorhexidine	4	19.000	0.000		19.000	19.000	**c**
	Saline	4	0.000	0.000		0.000	0.000	**a**
Streptococcus mutans	**Pomegranate**	4	7.250	4.856	**0.000***	-0.477	14.977	**a**
	Ginger	4	2.000	4.000		-4.365	8.365	**a**
	Cinnamon	4	25.125	7.750		12.793	37.457	**b**
	Chlorhexidine	4	35.000	0.000		35.000	35.000	**c**
	Saline	4	0.000	0.000		0.000	0.000	**a**
Staphylococcus aureus	**Pomegranate**	4	21.500	2.646	**0.000***	17.290	25.710	**b**
	Ginger	4	5.625	6.575		-4.837	16.087	**a**
	Cinnamon	4	18.000	4.082		11.504	24.496	**b**
	Chlorhexidine	4	17.000	0.000		17.000	17.000	**b**
	Saline	4	0.000	0.000		0.000	0.000	**a**
Candida albicans	**Pomegranate**	4	0.000	0.000	**0.000***	0.000	0.000	**a**
	Ginger	4	0.000	0.000		0.000	0.000	**a**
	Cinnamon	4	25.000	11.402		6.857	43.143	**c**
	Chlorhexidine	4	11.000	0.000		11.000	11.000	**b**
	Saline	4	0.000	0.000		0.000	0.000	**a**

Multiple Comparison Test, (MCT), where a<b<c significantly (p-value<0.05) and ab or bc means no significant difference between a and b or b and c (p-value >0.05)

While comparing the antimicrobial effect of *E. faecalis, S. mutans, S. aureus and C. albicans* within each of the extracted materials and control groups. Pomegranate and chlorhexidine demonstrated statistically significant differences between the different microbial strains investigated (p=0.000), while no statistically significant differences were observed within ginger (p=0.555), cinnamon (p=0.266) and negative saline groups as shown in Table 3.

Pomegranate exhibited a significant inhibition zone with *S. aureus* (21.500±2.646), whereas no significant differences were found between *E. faecalis* (12.250±4.573) and *S. mutans* (7.250±4.856). On the other hand, ginger and cinnamon presented no statistically significant differences between the different bacterial strains (p=0.555, p=0.266) respectively. Furthermore, no antifungal inhibitory zones were observed within the pomegranate and ginger extract groups (0.000±0.000), while the highest antimicrobial inhibition zone especially against *candida albicans* was exhibited in the cinnamon extract (25.000±11.402) followed by the chlorhexidine group (11.000± 0.000) which was statistically significant (p=0.000) as shown in Tables 2 and 3. Similarly, cinnamon had a significantly higher inhibitory potential against *streptococcus mutans* (25.125±7.750) compared to the other extract groups except for chlorhexidine (35.000±0.000).

The diameter of the antimicrobial inhibition zones (MIC) was measured along the vertical and horizontal axis in the different extract materials as shown in Figures 1 – 4. They represent different sizes based on their inhibitory potential in the chlorhexidine positive (Figure 1 A,B,C,) and saline negative control groups (Figure 1 D,E,F) versus ginger (Figure 2), cinnamon (Figure 3) and pomegranate (Figure 4) extracts.

Table 3: The antimicrobial inhibitory potential of *E. faecalis, S. mutans, S. aureus and C. albicans within* pomegranate, ginger, cinnamon extracts vs positive and negative control groups

Materials	Strain	N	Mean	Std. Deviation	*P*-value	95% Confidence Interval for Mean		MCT
						Lower Bound	Upper Bound	
Pomegranate	***E. Faecalis***	4	12.250	4.573	**0.000***	4.973	19.527	**b**
	S. mutans	4	7.250	4.856		-0.477	14.977	**b**
	S. aureus	4	21.500	2.646		17.290	25.710	**c**
	C. albicans	4	0.000	0.000		0.000	0.000	**a**
Ginger	***E. Faecalis***	4	4.500	9.000	**0.555**	-9.821	18.821	**a**
	S. mutans	4	2.000	4.000		-4.365	8.365	**a**
	S. aureus	4	5.625	6.575		-4.837	16.087	**a**
	C. albicans	4	0.000	0.000		0.000	0.000	**a**
Cinnamon	***E. Faecalis***	4	16.500	3.873	**0.266**	10.337	22.663	**a**
	S. mutans	4	25.125	7.750		12.793	37.457	**a**
	S. aureus	4	18.000	4.082		11.504	24.496	**a**
	C. albicans	4	25.000	11.402		6.857	43.143	**a**
Chlorhexidine	***E. Faecalis***	4	19.000	0.000	**0.000***	19.000	19.000	**c**
	S. mutans	4	35.000	0.000		35.000	35.000	**d**
	S. aureus	4	17.000	0.000		17.000	17.000	**b**
	C. albicans	4	11.000	0.000		11.000	11.000	**a**
Saline	***E. Faecalis***	4	0.000	0.000	**0.990**	0.000	0.000	**a**
	S. mutans	4	0.000	0.000		0.000	0.000	**a**
	S. aureus	4	0.000	0.000		0.000	0.000	**a**
	C. albicans	4	0.000	0.000		0.000	0.000	**a**

*Multiple Comparison Test, (MCT), where a<b<c<d significantly (p-value<0.05)

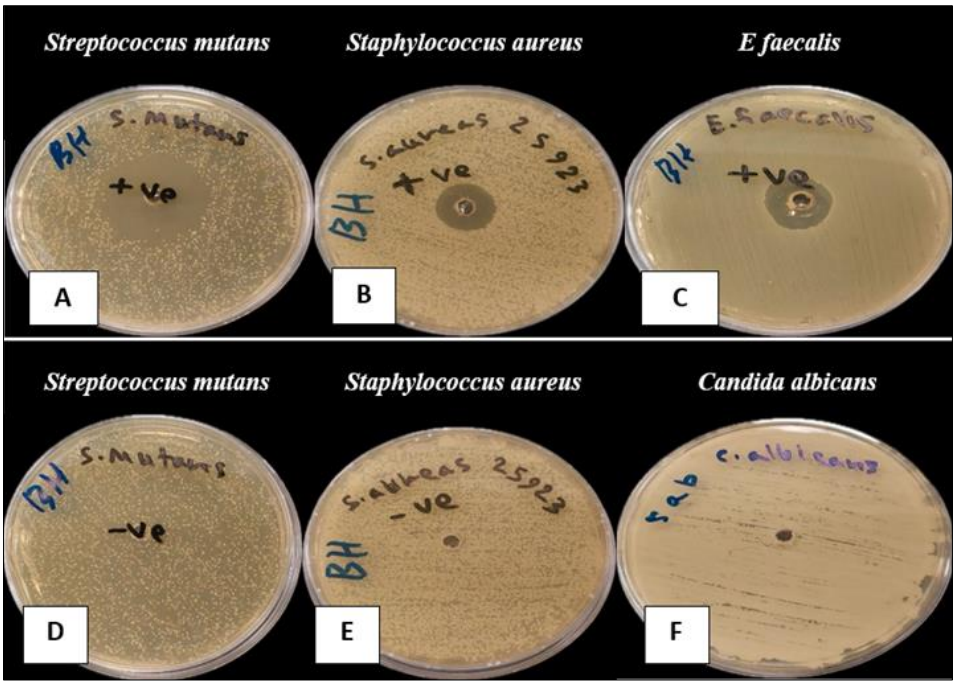


Figure 1: The Antimicrobial Inhibitory Effect of 0.2% Chlorohexidine Positive Control Group (A,B,C) and Saline Negative Control (D,E,F)

Figure 2: The Antimicrobial Inhibitory Effect of Ginger Extract

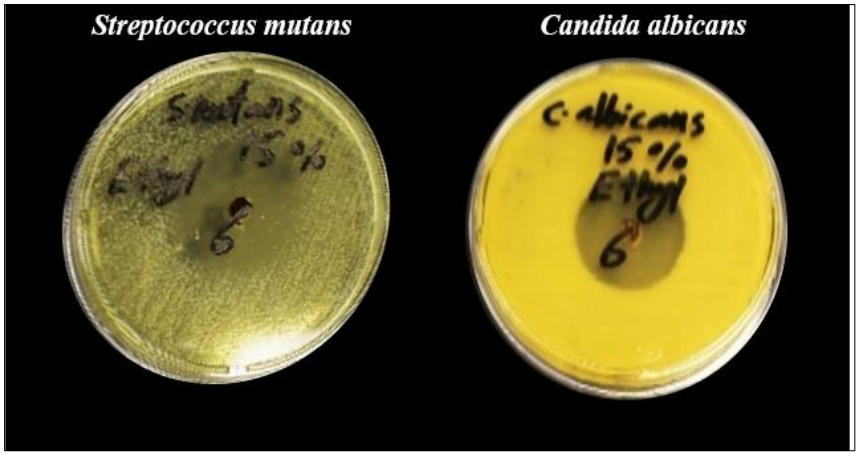


Figure 3: The Antimicrobial Inhibitory Effect of Cinnamon Extract

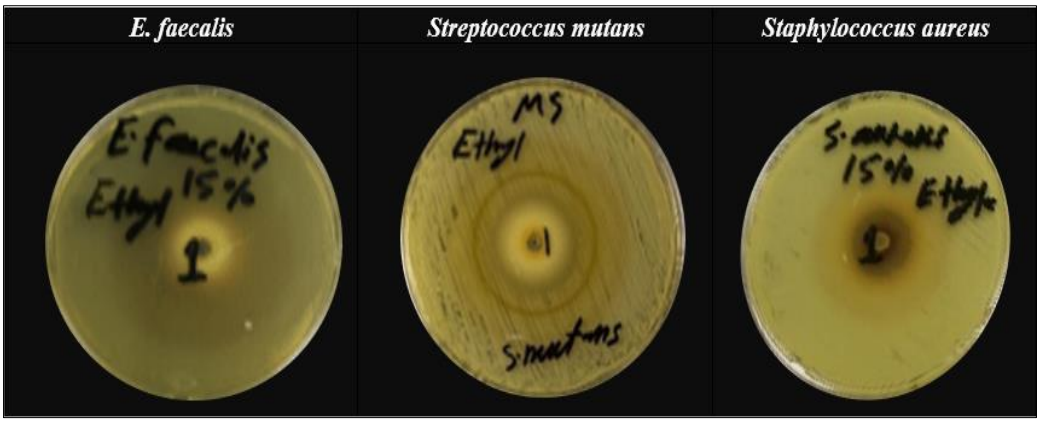


Figure 4: The Antimicrobial Inhibitory Effect of Pomegranate Extract

DISCUSSION

In recent years, there has been an increased interest in herbal medicine as an alternative treatment, with its use spreading worldwide over the past few decades [5-32]. Despite increased awareness and knowledge, still to this date, some people believe in primitive ways regarding oral health, preferring herbal over chemical medications, Coal for bleaching, Eugenol for toothache, Saline and *Myrrh* for mouth rinsing. Recently, there has been an increase in interest in ginger, cinnamon and pomegranate peel extracts as natural alternatives to conventional antimicrobial agents.

The following research was undertaken to compare the inhibitory antimicrobial effects of Ginger, Cinnamon, and Pomegranate peel extracts against *E. faecalis*. *S. mutans*, *S. aureus* and *C. albicans.*

Within the present study, statistically significant antimicrobial inhibitory effects were observed between and within the different extracted materials (p=0.000). Cinnamon, Ginger, and Pomegranate peel extracts exhibited statistically significant antibacterial effects against *Streptococcus mutans, Staphylococcus aureus, and Enterococcus faecalis*.

Cinnamon had a significantly higher inhibitory potential against *streptococcus mutans* in line with previous investigations, where they examined the antimicrobial activity of *Cinnamomum zeylanicum bark* extracts against dental caries pathogens, they reported that cinnamon essential oil inhibited *Streptococcus mutans* with a zone of inhibition (14.95±1) [6], in contrast, the inhibition zone observed in our study was notably higher than the previous findings (25.125±7.750) [38].

On the other hand, Ali and his colleagues showed that *Trans-Cinnamaldehyde* inhibit planktonic growth of the *E. faecalis* OG1RF strain with lower concentrations to that measured in the present study (16.500±3.873). The difference may be due to variations in the strains tested [39]. Moreover, cinnamon exhibited an average inhibition zone of (18.000±4.082) against *Staphylococcus aureus*, compared to that reported by Raeisi *et al*, which was higher in comparison to the present findings (28.50±0.60) [40].

The highest antimicrobial inhibition zone against *candida albicans* was remarkably exhibited in the cinnamon extract group (25.000±11.402) followed by the chlorhexidine group (11.000 ± 0.000) which was statistically significant (p=0.000) whereas the Ginger and Pomegranate groups did not exhibit similar effects. In line with a study carried out by Carvalho *et al.,* [41], where they compared the effects of extracted Cinnamon bark with Ethanol against *Candida albicans;* they found that the essential oil of cinnamon inhibited the growth of the *Candida albicans*, with minimal inhibitory concentrations (11.64±0.57) for the tested strains, these results are less than that observed in the present study [41].

The antimicrobial inhibitory effect of extracted Pomegranate peel against *Staphylococcus aureus was higher compared to E faecalis and S mutans* (21.500±2.646) in accordance to that reported by Khan and Hanee in a similar study , where they concluded that aqueous ethanolic extracts of *Punica granatum* peels (Pomegranate) have antibacterial properties with an inhibition zone of 25.5mm supporting our findings that ethanolic extract shows best result having zone of inhibition greater than that of the standard antibiotic Tetracycline (20.1mm) [42].

Similarly, Christy and Nivedhitha used 400 g of (mystique hills) Pomegranate peel powder mixed with 700 ml of 99.9% ethanol solvent against *E. faecalis and C. albicans and* showed a mean zone of inhibition of 26 mm^2 *against E. faecalis* in distinction to the present study where the inhibition zone was comparatively less than that previously reported (12.250±4.573). Furthermore, they showed a mean zone of inhibition 25mm^2 against *C. albicans* [43], contrary to our findings where pomegranate showed no apparent inhibition against *C. albicans* (0.000 mm). This contradistinction may be

attributed to the mode of preparation of the extracts and the type of pomegranate used.

Whereas Aldhaher *et al.*, reported an inhibition zone of 12.98 mm when using a 15 mg/mL concentration of pomegranate peel aqueous extract against *S. mutans*, which was slightly higher than that measured in our research (7.250±4.856) [44].

Algurairy reported that 25% concentration of pomegranate extracts showed an average inhibition zone of 22 mm against *S. aureus* which is similar to the present findings (21.500±2.646). He concluded that pomegranate peels have high antioxidant as well as antibacterial activity that may be used as medicine for humans, stating that it may reduce the cost and the risk of antibiotic consumption. Furthermore, the peels which are the byproduct could provide health benefits to humans and may be employed in food preservation and pharmaceutical purposes [45].

Similar to the pomegranate findings, the antimicrobial inhibitory effect of extracted ginger against *S. aureus was higher compared to E. faecalis and S. mutans* (5.625±6.575) in harmony to previous studies regarding antibacterial effect of cinnamon, garlic and ginger [46, 47], Karuppiah and Rajaram reached to a conclusion that minimum inhibitory effect of ginger ranged from 9.30 -13.55 mm which is considered higher in comparison to the present findings [46]. Whereas Priti *et al.,* added that the highest antimicrobial efficacy against *S. mutans* was observed in 0.2% Chlorhexidine, followed by 10% ethanolic extracts of cinnamon in comparison to 10% ethanolic extracts of ginger and garlic [47], supporting the present findings, where the cinnamon demonstrated the highest inhibition zones against *S. mutans, C. albicans, S. aureus and E. faecalis* compared to the ginger that showed the lowest inhibition zones.

Likewise, Giriraju and Yunus in an in-vitro study demonstrated that the zone of inhibition of 10% ethanolic ginger extract against *E. faecalis* and *C. albicans* varied between 10 – 14 and 9 – 11 mm respectively, depending on the concentration, which is more or less high than our observations against *E. faecalis* (4.500±9.000). Besides, within the present study ginger had no effect on *C. albicans* (0.000 mm), different types of microbial strains and variations in the ethanolic extract preparation in their research (10% instead of 15%) might explain the reason for this inconsistency [12].

The lowest inhibitory zone was detected within the ginger extract group against *S. mutans* (2.000±4.000), compared to that reported by Nada where she stated that the antibacterial activity of ginger leaves oil nano-emulsion against *S. mutans* had a higher inhibition zone of 25 mm, although same strain of bacteria was used, a huge discrepancy took place [2]. Similarly, the antimicrobial effect of 15 % ethanolic ginger against *S. aureus* was lower than previous studies [48].

Regarding the positive control group, Chlorhexidine is the most effective chemotherapeutic agent against *S. mutans* (35.000±0.000), as confirmed in the present study followed by *E. faecalis, S. aureus and C. albicans* (19.000;17.000;11.000) respectively [49].

The overall clinical relevance of this research is that these plant extracts are promising in integrative medicine and may reduce dependence on synthetic antimicrobials. They may work synergistically with antibiotics, potentially reducing required doses and minimizing side effects. Their diverse mechanisms of action may help combat resistant strains where conventional antibiotics fail. They are generally safe, affordable, and culturally acceptable across many populations worldwide.

CONCLUSION

Cinnamon, Ginger, and Pomegranate exhibited prominent antibacterial inhibitory effects that hold potential for preventive and therapeutic applications. Particularly, Cinnamon showed the most significant antimicrobial activity against *Streptococcus mutans* and exhibited an *anti-candidal* inhibitory effect.

However, further in-vivo and clinical studies are necessary to validate the safety and efficacy of cinnamon, ginger, and pomegranate-based dental products, as well as to determine their optimal formulations and long-term effects.

The Limitation of this Study

The study focused on four microorganisms, mainly *Streptococcus mutans, Staphylococcus aureus, Enterococcus faecalis and Candida albicans* that are associated with dental caries and oral thrush. The research was conducted on a small scale in-vitro samples, within a controlled aseptic environment, without the presence of saliva, which may have a synergistic antibacterial effect. Variability in active compound concentrations across preparations is another issue for accurate standardization.

As a consequence, further research is needed to evaluate the antimicrobial effect of Cinnamon, Ginger, and Pomegranate on Red complex bacteria, which are responsible for periodontal diseases, in-vivo or clinical trial studies using artificial saliva, would provide more insight into their practical applications.

Clinical Significance

The clinical significance of the antimicrobial effects of ginger, cinnamon, and pomegranate lies in their potential as natural alternatives or adjuncts to conventional antimicrobial agents, especially in the face of rising antibiotic resistance.

Conflict of Interest: The authors declare that there is no conflict of interest regarding the publication of this paper.

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Availability of Data and Materials: The data and materials supporting the results reported in this research are available on request from the corresponding author.

Contributions of Authors and co-Authors:

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