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Antimicrobial Activity of Some Commercial Toothpastes and Antibiotics on Two Oral Pathogenic Bacteria—An *in-Vitro* Study

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Abstract

Oral health problems such as periodontal diseases, dental caries, and endodontic infections have a significant negative impact on oral health and impose a substantial financial burden on the global population. The prevalence of these issues is increasing due to the buildup of bacterial plaque and the growing resistance of bacteria to antimicrobial treatments. The aims of this study to evaluate the anti-bacterial activity of four types of antibiotics (Amoxicillin, Augmentin, Azithromycin and Metronidazole) and four types of toothpastes (Sensodyne, ipana, denta and cariax Gingival Kin) on two oral pathogenic bacteria (*Streptococcus mutans* and *Staphylococcus epidermidis*). Bacterial samples of previously isolated *Streptococcus mutans and Staphylococcusepidermidis* were used as test organisms and the Kirby-Bauer disc diffusion method was employed to assess the antibacterial efficacy of various antibiotics and evaluate the impact of different toothpastes using a filter paper disc agar measurement technique. Each filter disc was saturated with toothpaste solution in a test tube for approximately 30 to 40 seconds, after which they were placed on Mueller-Hinton broth bacterial cultures in petri dishes. These Petri dishes were then incubated at 37˚C for 24 hours, and the clear zone's diameter (inhibition zone in mm) was subsequently measured and the results were recorded. The results demonstrated that Sensodyne toothpaste and Metronidazole antibiotic were ineffective against both types of bacteria, while Augmentin and Amoxicillin were effective by high diameter inhibition zones of growth against *S. mutans* and Azithromycine against *S. epidermidis*. Also Ipana, Denta, and Cariax Gingival Kin toothpastes exhibited a moderate effect against the two bacteria. This study suggests that certain antibiotics and toothpastes can effectively inhibit the growth of harmful oral bacteria, but not

all of them are effective.

Keywords

Antibacterial Effect, Antibiotics, Toothpastes, *Streptococcus mutans, Staphylococcus epidermidis*

1. Introduction

Oral health is widely recognized as an essential aspect of overall health and wellbeing [1]. The mouth plays a vital role in the digestive process, as it is where food is first broken down and prepared for further digestion and absorption. To effectively masticate food and facilitate proper digestion, it is essential to maintain healthy teeth [2]. The oral cavity is host to a diverse array of bacterial flora, some of which have been identified as causative agents of various oral diseases and conditions [3]. More than 700 unique bacterial species have been detected in the oral cavity. While the majority of these bacteria are harmless, some have the potential to cause damage [4] [5]. Poor oral hygiene is one of the reasons for accumulation of microbes and their harmful activities in the mouth of individuals. In many individuals, the oral hygiene method of tooth brushing is, by itself, usually insufficient and ineffective over a long period to provide control on the formation of plaque consistent with oral health [6] [7]. Many microbial species have the ability to colonize and attach to the mouth cavity, where they can lead to a number of infectious disorders, including dental infections [8]. Depending to the many studies the most common bacteria found in oral cavity are*Streptococcus mitis, Streptococcus oral, Streptococcus sanguis, Streptococcus mutans, Streptococcus gordonii, Staphylococcus aureus, Staphylococcus epidermidis, Veillonella sp., Neisseria sicca, Fusobacteria sp., Actinomyces sp., Corynebacterium sp., Lactobacilli sp. and Prevotella sp* [3]. The primary opportunistic pathogen of dental caries, which can demineralize the enamel, is known to be *Streptococcus mutans* [6]. *S. mutans* is a member of the oral flora and has been shown to be a key player in the development of dental caries because of its ability to convert fermentable carbohydrates into organic acids [9]. *Streptococcus mutans*, a gram-positive, facultative anaerobic bacteria, was discovered in a prior investigation after being isolated from carious lesions [10]. The *Streptococcus mutans* has the capacity to produce dental plaque by the release of the mucous and most sticky substance known as dextran or glucan. Plaque is created when they adhere to the gums' flat surfaces. Hence, if the most significant bacteria especially *S. mutans*, is removed from the mouth, the risk of dental caries is decreased [2], also avoid additional risks as well because *S. mutans* can occasionally result in infected endocarditis after bloodstream invasion during invasive dental procedures like tooth extractions [10]. Among the coagulase-negative staphylococci, the most clinically significant one is *Staphylococcus epidermidis*. It is a gram-positive bacterium that does not form spores, lacks motility, and is facultative anaerobic. *S. epider-*

midis is also catalase-positive, distinguishing it as a staphylococcal species [11]. Despite being an opportunistic pathogen, *S. epidermidis* plays a crucial role in maintaining the balance of skin microflora and acts as a reservoir for resistance genes. Also treatment of *S. epidermidis* infections is challenging due to the presence of specific antibiotic resistance genes and the formation of biofilms [12]. The emergence of resistance to multiple antibiotics, including methicillin and vancomycin, poses a significant challenge in the treatment of infections caused by Staphylococcus species [13] [14], *S. epidermidis* strains acquire resistance determinants through gene acquisition and genetic recombination. A study conducted in 2011 found that over 70% of *S. epidermidis* strains were resistant to methicillin (oxacillin). This highlights the prevalence of methicillin resistance in *S. epidermidis* populations [15]. Biofilms are multicellular clusters that exhibit inherent resistance to antibiotics and evade host defense mechanisms, further complicating the treatment process [12]. Plaque buildup, dental caries, and periodontal disorders are the three main categories of dental issues [6]. Dental caries is a bacterial condition that affects the calcified tissues of the teeth and is characterized by the demineralization of the inorganic and the destruction of the organic components of the tooth. The disintegration of teeth owing to acids produced by bacteria is known as tooth decay, dental caries, or cavities [8].

The most common reasons patients seek dental care are usually related to periodontal diseases (such as gingivitis and periodontitis) and dental caries (tooth decay) [6]. The dental biofilm, which is found on hard surfaces in the oral cavity, contains cariogenic bacteria as well as host components such polysaccharides and cell-free enzymes, which confirms etiopathogenesis of dental caries has been linked to biofilms [16]. A very serious problem is the exponential development in multidrug-resistant (MDR) bacteria that are resistant to current medicines because they are the main cause of treatment failure and have raised the death rate [17]. Consequently, the proposal of chemical agents with anti-plaque or antimicrobial activity included in dental products has been made as a potential preventive method of reducing plaque-mediated disease [7]. Chlorhexidine is one of plaque control, possesses bactericidal and bacteriostatic properties, making it effective in the oral cavity. However, it is associated with several side effects, such as extrinsic tooth staining, taste alterations, discoloration, swelling of the parotid gland, and the development of microbial resistance. These drawbacks make long-term use of chlorhexidine unfavorable despite its effectiveness [16].

Currently, there is an increasing trend of bacterial resistance to multiple drugs, including ampicillin, kanamycin, gentamicin, and tetracycline. This resistance can contribute to the development of gingivitis, which, if left untreated, can progress to more serious conditions [18]. The rising drug resistance of *S. epidermidis* is a growing concern worldwide [19]. *S. epidermidis* strains are frequently resistant to antibiotics, making them multidrug-resistant, and they are a common cause of infection in both patients and healthy individuals [15]. On the other hand, *S. mutans* is generally susceptible to most antibiotics, including am-

picillin, clindamycin, and vancomycin, except for bacitracin and erythromycin, to which it shows resistance [20]. Clindamycin appears to be the most effective therapeutic agent for managing dental caries caused by *S. mutans*. These findings highlight the urgent need to address the global problem of drug resistance in both *S. epidermidis* and *S. mutans* for effective treatment strategies [21]. Recent research has highlighted that sub lethal doses of antibiotics can lead to bacterial resistance and unintentionally promote biofilm formation [14]. In terms of effectiveness against *S. mutans*, studies have shown that amoxicillin and penicillin G are highly effective, while erythromycin, vancomycin, and clindamycin exhibit moderate effectiveness. However, metronidazole, ciprofloxacin, and rifampicin lack inhibitory activity against these bacteria [22]. Toothpaste gets rid of stains and bad breath. Periodontal diseases and other oral infections are significantly reduced by their formulations and active components [3]. Toothpaste aims to reduce oral bacterial flora and deliver fluoride, with the ultimate goal of improving dental health [23]. The majority of the toothpastes have relatively similar chemical compositions, however they vary in terms of how well they inhibit the examined bacteria. Some toothpastes demonstrated less potential to inhibit the examined bacteria, despite some having stronger antimicrobial properties. The concentration of active ingredients used in creating various toothpastes may be the cause of this difference [24]. While most toothpastes exhibit antibacterial effects against *S. mutans*, they may also have toxic effects on epithelial cells, which can worsen over time [6]. Some experimental toothpastes showed no inhibitory effect on *Candida albicans* and had minimal impact on *S. mutans* [25]. However, the need for prolonged use of antimicrobial oral care products to control dental plaque highlights the importance of raising awareness about the presence of multidrug-resistant bacteria in dental plaque [5].

The aim of this in vitro experimental study was to assess the antibacterial efficacy of four distinct toothpaste variants and four commonly employed antibiotics against two oral pathogenic bacteria: *Streptococcus mutans* and *Staphylococcus epidermidis*. It was discovered that the antibiotic metronidazole and the toothpaste Sensodyne were ineffective on both strains of bacteria. Furthermore, varying levels of effectiveness were observed for the other antibiotics and toothpastes, signifying their varying abilities in combating the bacteria responsible for oral and dental issues.

2. Material and Method

2.1. Study Design and Material

An in vitro experimental design was adopted to conduct the study.Four different brands of toothpastes were evaluated, and their names and details can be found in **Table 1**.

Additionally, four types antibiotics (Amoxicillin 25 mg, Augmentin 30 mg, Metronidazole 5 mg, and Azithromycin 15 mg) manufactured by the Oxoid company in the UK, were tested against the two types of bacteria (*Streptococcus mutans* and *Staphylococcus epidermidis*).

Table 1. Toothpastes evaluated in the study, ingredients and manufacturer.

No	Toothpastes	Ingredients	Manufacturer
1	Sensodyne (TP1)	Aqua, Hydrated Silica, Sorbitol, Glycerin, Pentasodium Triphosphate, Potassium Nitrate, PEG-6, Alumina, Aroma, Titaanium Dioxide, Sodium Methyl Cocoyl Taurate, Cocamidopropy Betaine, Xanthan Gum, Sodium Hydroxide, Sodium Saccharin, Sodium Fluoride 0.315% PM Fluoride (14SOP) includes.	Turkey
2	Ipana (TP2)	Glycerin, Hydrated Silica, Sodium Hexametaphosphate, Aqua, PEG-6, Aroma, Trisodium phosphate, Sodium Lauryl Sulfate, Sodium Saccharin, Carrageenan, Cocamidopropyl Betaine, Sodium Fluoride, Xanthan Gum, CI77891, Lemonene, Mica, Sucralose, Pearl Powder, Sodium Benzoate, Sodium Hydroxide, Citric Acid, Sodium Citrate, Potassium Sorbate.	Germany
3	Denta (TP3)	Sorbitol, Aqua, Hydrated Silica, Glycerin, PEG-8, Sodium Lauryl Sulfate, Aroma, Dicalcium phosphate Dihydrate, Cellulose Gum, Sodium Fluoride, Sodium Saccharin, Xanthan Gum, Lemonene, Eugenol, CI74160.	Turkey
4	Cariax Gingival Kin (TP4)	Aqua, Sorbitol, Glycerin, Hydrated Silica, Cocamidopropy Betaine, Titanium Dioxide, Xanthan Gum, Aroma, Sodium Fluoride (0.22%), Sodium Methylparaben, Chlorhexidine Digluconate (0.12%), Menthol, Sodium Saccharin, Methyl Salicylate, Eugenol.	Spain

2.2. Preparation and Reactivation of the Microorganisms

Bacterial samples of previously isolated *Streptococcus mutans* and *Staphylococcus epidermidis* were used as test organisms in a research investigation. After vortexing, 0.1 ml of the suspension was taken from the tube and streaked onto blood and chocolate agar plates. The chocolate agar plates were incubated anaerobically at 37˚C for 24 hours, while the blood agar plates were incubated aerobically. This culturing process was carried out to activate the bacteria for further analysis, Figure 1. After obtaining a sufficient amount of bacterial colonies, they were examined using the BD Phoenix™ M50 device. The results obtained from the device confirmed the presence of the two types of bacteria.

2.3. Agar Disc Diffusion Technique

Staphylococcus epidermidis and *Streptococcus mutans* colonies were selected for the experiment. To begin, 5 ml of sterile nutrient broth was inoculated with these colonies. The mixture was then incubated at 37˚C for a period of 2 to 8 hours, maintaining anaerobic conditions for *S. mutans*, until a moderate level of turbidity developed. In accordance with the World Health Organization's (W.H.O.) recommendation, a solution was prepared by combining 0.5 ml of 1.75% barium chloride with 99.5 ml of 0.36N sulfuric acid. This solution was used to compare the turbidity of the inoculum. To ensure comparable turbidity levels, the inoculum was either diluted or incubated for an extended period, as necessary. Furthermore, this culture was utilized to create a lawn culture on Mueller-Hinton agar. The Kirby-Bauer disc diffusion method was carried to determine the antibacterial effect of each of the antibiotics [2] [22] [26].

To determine the antibacterial effect of toothpastes, standard-sized filter discs

Figure 1. Growth of bacterial colonies on blood agar and chocolate agar medium: (a) *Streptococcus mutans* on blood agar, (b) *Streptococcus mutans* on chocolate agar, (c) *Staphylococcus epidermidis* on blood agar and (d) *Staphylococcus epidermidis* on chocolate agar.

were cut and sterilized using an autoclave. Approximately 10 grams of each toothpaste were mixed with 10 ml of sterilized water in a test tube, each filter disc was then soaked in the toothpaste solution for 30 - 40 seconds and placed on a culture plate containing lawn cultures of *Streptococcus mutans* and *Staphylococcus epidermidis*, which were grown on Mueller-Hinton agar [2]. A filter disc soaked in sterilized distilled water without toothpaste served as the negative control [2] [6], while a mouthwash containing 0.2% chlorhexidine digluconate, manufactured in Turkey, was used as the positive control in the study [27]. The plates were incubated at 37˚C for 24 hours. After the incubation period, the diameter of the clear zone (inhibition zone) was measured in millimeters, and the results were recorded.

2.4. Statistical Analysis

The experiment was performed in triplicate for each toothpaste, and Microsoft Excel was used to calculate the mean value and standard deviation.

3. Results

In this study, screening was performed to evaluate the antibacterial activity of chosen antibiotics and toothpaste products against bacterial strains cultivated in a culture medium. **Figure 1** illustrates the significant growth observed for both *S. mutans* and *S. epidermidis* on both blood agar and chocolate agar media following the activation of bacteria through cultivation and incubation.

The efficacy testing of antibiotics on *S. epidermidis* bacteria demonstrated high susceptibility to Azithromycin, resulting in a 25 mm diameter inhibition zone. This was followed by Augmentin with a 20 mm diameter and Amoxicillin with a 14 mm diameter. On the other hand, for *S. mutans* bacteria, Augmentin exhibited the highest antibiotic effect with a 40 mm diameter inhibition zone, followed by Amoxicillin with 38 mm and Azithromycin with 21 mm. Both types of bacteria showed no sensitivity to Metronidazole (**Table 2** and **Figure 2**).

The evaluation of various toothpaste brands' efficacy against *S. mutans* and *S. epidermidis* bacteria involved the measurement of the zone of inhibition, as illustrated in **Figure 3**. Each experiment underwent three repetitions, and the average

Table 2. Effect (inhibition zone in millimeter) of antibiotics on study bacteria.

Bacteria	Amoxicillin (AMX)	Augmentin (AMC)	Azithromycin (AZM)	Metronidazole (MET)
Staphylococcus epidermidis	14 (MS)	20 (S)	25 (S)	0 (NA)
Streptococcus mutans	38 (S)	40 (S)	21 (S)	0 (NA)

S = Sensitive, MS = Moderately sensitive and NA = Not Active.

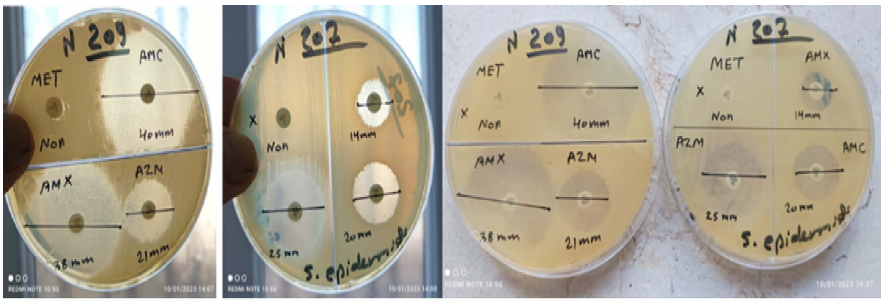

Figure 2. Illustrates a visual representation of the results obtained for *S. epidermidis* and *S. mutans*, showcasing the varying sizes of the inhibition zones caused by different antibiotics.

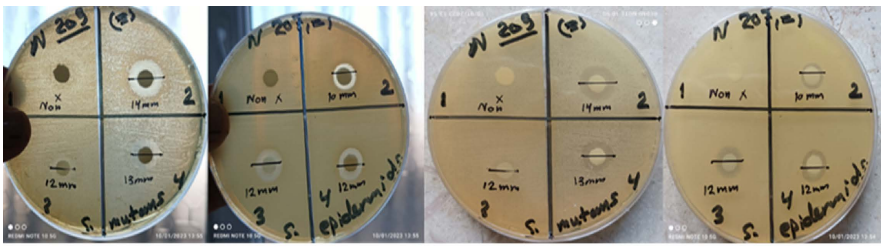

Figure 3. Illustrates the effect of different toothpaste brands on *S. mutans* and *S. epidermidis* bacteria in a single experiment. The chart provides a visual representation of the inhibition zones observed for each toothpaste brand against both bacterial species.

of these triplicate measurements was documented. The mean values and standard deviations of the inhibition zones were then computed and presented in Table 3. Analysis of the average data from three separate experiments of toothpastes brands revealed that Sensodyne did not manifest a significant impact on either type of bacteria. Conversely, the othertoothpaste brands displayed a moderate inhibitory effect against these bacterial strains.

Specifically, Cariax Gingival Kin displayed the highest zone of inhibition against *S. mutans*, measuring 14.67 mm, followed by Ibana with 12.33 mm and Denta with 11.33 mm. Against *S. epidermidis*, the highest zone of inhibition was observed with Denta, measuring 11.33 mm, followed by Cariax Gingival Kin with 11 mm and Ipana with 9 mm. As a positive control, mouthwash containing

Table 3. Efficacy of toothpastes against *S. mutans* and *S. epidermidis* Bacteria (average of triplicate inhibition zone in mm).

S. No	Toothpaste Brand	Manufacture place	Average Zone of Inhibition on Bacteria (mm)	
			S.mutans	*S.epidermidis*
1	Sensodyne (TP1)	Turkey	0.00 ± 0.00	0.00 ± 0.00
2	Ipana Pearl Glow (TP2)	Germany	12.33 ± 2.89	09 ± 10
3	Denta Etkin koruma (TP3)	Turkey	11.33 ± 1.15	11.33 ± 1.15
4	Cariax Gingival Kin (TP4)	Spain	14.67 ± 1.53	11.00 ± 1.73
5	Chlorhexidine (CHX) +ve	Spain	20.33 ± 4.04	16.33 ± 4.04
6	Distilled water (DSW) −ve	Tunisia	0.00 ± 0.00	0.00 ± 0.00

TP = Toothpaste, +ve = positive control, −ve = Nigative control, Mean value ± standard deviations.

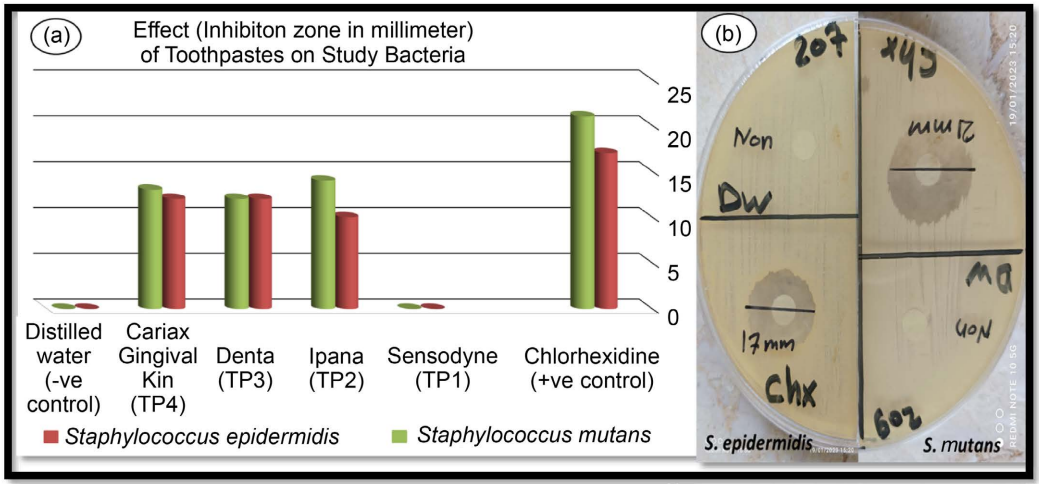

Figure 4. (a) illustrates the effect of toothpaste brands on *S. mutans* and *S. epidermidis* bacteria in a single experiment. (b) The effect of mouthwash containing 0.2% chlorhexidine digluconate (Chx) as a positive control and distilled water (Dw) as a negative control on both types of bacteria.

0.2% chlorhexidine digluconate exhibited a zone of inhibition measuring 20.33 mm against *S. mutans* and 16.33 mm against *S. epidermidis* bacteria. The negative control, consisting of distilled water, showed no effect against both types of bacteria, as detailed in Figure 4 and Table 3.

4. Discussion

Dental problems are primarily caused by inadequate oral hygiene practices. The main etiological factor in dental disorders is the formation of plaque on the teeth. Dental plaque develops due to the accumulation of oral pathogenic microflora, leading to the formation of a dense and complex microbial community that ultimately results in the degradation of the hard enamel tissue [28]. The oral microflora maintains a delicate balance of bacteria, and any disturbance to this equilibrium can result in the emergence of potentially pathogenic bacteria and the initiation of disease processes. It is widely recognized that the disruption of this bacterial balance plays a critical role in the development of oral diseases

[25]. Additionally, it is imperative to evaluate all medications, products, and chemical agents used in dental practice for their potential cytotoxicity, resistance, and any other changes to ensure their effectiveness against bacterial changes and resistance [6].

In this experimental study (*in vitro*), we examined the antimicrobial effectiveness of four different antibiotics and four toothpaste brands against two bacterial species, specifically *S. mutans* and *S. epidermidis*. Following the guidelines outlined by the Clinical and Laboratory Standards Institute [29], our findings showed that Augmentin and Azithromycin were effective against both bacterial strains. Amoxicillin demonstrated efficacy against *S. mutans* and exhibited moderate effectiveness against *S. epidermidis*. Conversely, Metronidazole was found to be ineffective against both bacterial species. These results align with previous studies, that demonstrated the ineffectiveness of Metronidazole against *S. mutans* and the beneficial effect of Amoxicillin against this bacterium [22] [30]. Another study by Salh *et al*. further corroborated the effectiveness of Amoxicillin and several other antibiotics against three strains of *S. mutans* [20]. Moreover, it was at odds with the findings of another study by Jubair, which established that *S. mutans* bacteria were resistant to a number of medications, including Amoxicillin [31], also align with a previous study that investigated the impact of several antibiotics on *S. mutans* conducted by Salinas *et al*., this study demonstrated that the majority of strains exhibited high sensitivity to antibiotics like Augmentin, Amoxicillin, and Azithromycin, and there was a substantial level of resistance to metronidazole, and there were variations compared to this study including a small percentage of resistance to Augmentin and Amoxicillin and a moderate percentage of resistance to Azithromycin among some strains. Additionally, a small percentage of strains showed sensitivity to metronidazole [32]. On the other hand, the findings also are consistent with a study conducted by Gunawan *et al*., which reported a high sensitivity of *S. epidermidis* to Augmentin and Amoxicillin. However, there was a partial discrepancy as their study indicated that these bacteria were not sensitive to azithromycin [33]. Our study's findings also showed partial agreement with Brescó Salinas *et al*.'s research concerning the sensitivity of most Gram-positive cocci, including *S. epidermidis*, to Augmentin, amoxicillin, and azithromycin. Likewise, our results concurred with their observations of resistance in many species to metronidazole. However, differed in fact were noted, particularly in the sensitivity of some types to metronidazole and the resistance of other types to Augmentin, amoxicillin, and azithromycin [32]. Also, our results were partially in line with a study conducted by Nicolosi *et al*., which assessed a range of antibiotics against *S. epidermidis*. This study highlighted the sensitivity of certain strains of these bacteria to Augmentin and azithromycin, albeit with some variations in resistance observed among other strains towards these two antibiotics [34]. Additionally, the results affirmed that *S. mutans* bacteria displayed a greater susceptibility to the Augmentin and Amoxicillin when compared to *S. epidermidis*. This observation is consistent with earlier studies that have elucidated distinctions in cell wall thickness, antibiotic re-

sistance profiles, and the formation of protective biofilms in *S. epidermidis*, all of which contribute to the increased difficulty in treating this bacterium [11] [15].

Toothpastes can enhance the effectiveness of oral hygiene practices in various ways, also they can prevent bacteria from sticking to the teeth, slow down the accumulation of plaque, and reduce the number of bacteria in saliva. The antimicrobial properties of these products are typically evaluated using the agar diffusion method, which measures the zones of inhibition against specific microorganisms [25]. Numerous studies have delved into the impact of toothpaste on pathogenic bacteria in the oral and dental environment. These investigations encompass evaluations of the efficacy of locally available toothpaste brands within the study region [2], comparisons between the effectiveness of mouth rinses and toothpaste [7] [28], and a focus on toothpaste formulations enriched with natural components like Theobromine or Chitosan [27]. Additionally, some studies have provided evidence for the effectiveness of toothpaste formulations containing active ingredients such as triclosan and fluoride against various bacteria, including *Staphylococcus sp* and *Streptococcus sp* [3]. Recently reported by Dhakal *et al.* that the collaboration between natural ingredients and chemotherapy in toothpaste has also been shown to combat positive and negative oral pathogenic bacteria [35]. Furthermore, research has highlighted disparities in the effects of toothpaste containing different components like ozone, ganoderma lucidum, tea tree oil, xylitol, zinc, propolis, theobromine, triclosan, and sodium lauril sarkosinate on *S. mutans* [36]. In addition the study conducted by Oluboyo *et al.* have even demonstrated variations in the impact of toothpaste containing the same ingredients on some types of bacteria, contingent upon their concentration levels [24]. Moreover, another study revealed the effectiveness of powdered toothpaste in removing biofilms associated with bacteria that contribute to tooth decay, ultimately reducing the incidence of cavities [4]. However, our study showed that Sensodyne toothpaste was found to be ineffective against the tested bacteria, and other toothpaste brands such as Ipana, Denta, and Cariax Gingival Kin demonstrated only moderate effectiveness. This aligns with a previous study by Guven *et al.*, which also observed that certain toothpastes did not lead to significant sensitivity [25]. Another study by Ali *et al.*, revealed that although Sensodyne toothpaste was effective, it was less effective compared to other toothpastes in their research [2]. These findings highlight the importance of focusing on improving and enhancing the impact and synergy of toothpastes to effectively address oral and dental health concerns.

5. Conclusion

In light of the dynamic nature of microbial behavior, the emergence of antimicrobial resistance, and bacteria's capacity to adapt to these antimicrobials, ongoing research and investigations into these agents are imperative. This study has concluded the effectiveness of Augmentin, Amoxicillin, and Azithromycin against both *S. epidermidis and S. mutans*, which are commonly found in the

oral cavity and associated with dental issues. In contrast, Metronidazole was found to be ineffective against these bacteria. Furthermore, toothpaste brands such as Ipana, Denta, and Cariax Gingival Kin exhibited moderate effectiveness, while Sensodyne toothpaste proved ineffective. These findings underscore the need for enhancing the efficacy of some antimicrobial and reconsidering their usage mechanisms to effectively address oral and dental health concerns.

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Consent for Publications

The authors have reviewed the manuscript and grant permission for the publication of its final version.

Availability of Data and Material

The authors can provide data upon request.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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