



Evidence on Antimicrobial Efficacy of Commercial Toothpaste

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Authors' contributions

This work was carried out in collaboration between both authors. Author MF performed the literature search, carried out laboratory analysis and wrote the first draft of manuscript. Author AZN wrote the literature search and carried out the laboratory analysis. Both authors read and approved the final manuscript.

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ABSTRACT

This study aims to determine the antimicrobial activity of different brand of commercially available toothpaste in Malaysian outlet, namely Colgate-Total, Mu'min, Tesco and Safi against selected oral microbiome. All the different toothpastes brand were tested for their antimicrobial activity against five oral pathogens namely *Staphylococcus aureus*, *Proteus mirabilis*, *Salmonella typhi*, *Klebsiella pneumonia* and *Escherichia coli* by using agar well diffusion method. Colgate-Total brand has the highest mean zone of inhibition (Z.O.I) on the test organisms (30.7 mm) followed by Safi brand (29.2 mm) and Tesco brand (12.5 mm) while Mu'min brand showed the least activity on the test micro-organisms (2.4 mm). The present work found Colgate-total brand toothpaste more effective in controlling pathogenic oral microflora as compared to other brand of toothpaste.

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1. INTRODUCTION

Oral diseases remain a major health problem worldwide [1]. Oral health survey of adults conducted by Ministry of Health Malaysia, Malaysia indicated that the number of periodontal disease is increasing continuously from 1990 to 2010 [2]. There is high correlation between oral diseases and growth of microorganism [3]. Periodontal diseases which is caused by plaque formation is defined as bacterial infections that cause disturbance of the supporting structure of the teeth such as gingival, cementum, periodontal membrane and alveolar bone [4]. Plaque formation results from the accumulation of dietary carbohydrates on the surface of teeth that interact with bacteria. Bacterial metabolic products formed in plaque constantly react with salivary constituents on tooth surface, thus lead to dental caries [5].

There are numbers of microorganisms which are associated with formation of dental caries such as *Staphylococcus aureus*, *Proteus mirabilis*, *Salmonella typhi*, *Klebsiella pneumonia* and *Escherichia coli*. Amongst them, *E. coli* is the most common microorganism responsible for the formation of oral cavity [4].

Recently, huge numbers of oral hygiene products were introduced to public that claimed to provide maximum protection against periodontal disease. Basically, the efficacy of each toothpaste lies on its capability to retard growth of pathogenic oral microflora. Many oral toothpaste companies also claimed the addition of chemical agents with antiplaque or antimicrobial activity into dental products which served as a potential prophylactic method of reducing plaque mediated disease. This present investigation aimed to investigate antimicrobial efficacy of different commercial toothpastes against selected oral microbiome by using a standard basic procedure. It is noteworthy that, the present result obtained from this research will provide useful evidence to the public to support the benefit of daily usage of current toothpaste to prevent oral disease.

2. MATERIALS AND METHODS

2.1 Bacterial Strains and Growth Media

The bacteria used in this study were wild type isolates of *Staphylococcus aureus*, *Proteus mirabilis*, *Salmonella typhi*, *Klebsiella pneumonia*

and *Escherichia coli* which were donated by Mr. Dhana Raj from Asian Institute of Medical Sciences and Technology University (AIMST), Sungai Petani, Malaysia. Microorganisms were maintained using Mueller Hinton Agar (Oxoid, UK) and were sterilized at 121°C and 15 psi for 20 minutes before use. Suspension of each microbial cultures (*S. aureus*, *P. mirabilis*, *S. typhi*, *K. pneumonia* and *E. coli*) were prepared accordingly using 0.5 McFarland standards (approx., 10^8 cfu/mL) for further use in antibacterial assay.

2.2 Preparation of Toothpaste

Toothpastes used in this study were Mu'min premium (Al-Meswak Mu'min, Malaysia), Tesco Pro-tech (Tesco, Malaysia), Safi complete care (Wipro Unza, Malaysia) and Colgate-Total (Colgate Palmolive, Malaysia). All toothpastes were prepared as 2:5 and 4:5 stock concentration by mixing 2 g or 4 g of each various toothpastes in 5 ml of sterile distilled water. As for 100% concentration, toothpastes were directly inserted in the media wells without any dilution.

2.3 Antibacterial Assay

Microorganisms were exposed to the different toothpaste concentrations (2:5 and 4:5) using an agar based assay [6,7]. 100 µl of each isolate was spread uniformly over Mueller Hinton Agar (MHA) medium by using a cotton swab. Five mm wells were formed on the agar plates using a sterile cork borer and aliquots (100 µL) of toothpaste each at different concentrations were deposited into the well (Fig. 1). The well at the center was placed with tap water which acts as a negative control. Each experiment for different toothpastes was done in triplicate. Inhibition activities against microbial strains were determined by measuring the zones of inhibition formed around the well in millimeter (mm) after 24 h of incubation at 37°C.

2.4 Statistical Analysis

Statistical analyses were performed using GraphPad Prism 5 (GraphPad Software Inc., San Diego, CA, EUA) by applying one way ANOVA to assess the significance of change between experimental groups and control (tap water). The data were expressed as mean ± Standard Deviation (SD) and p-value <0.05 was considered as statistically significance.

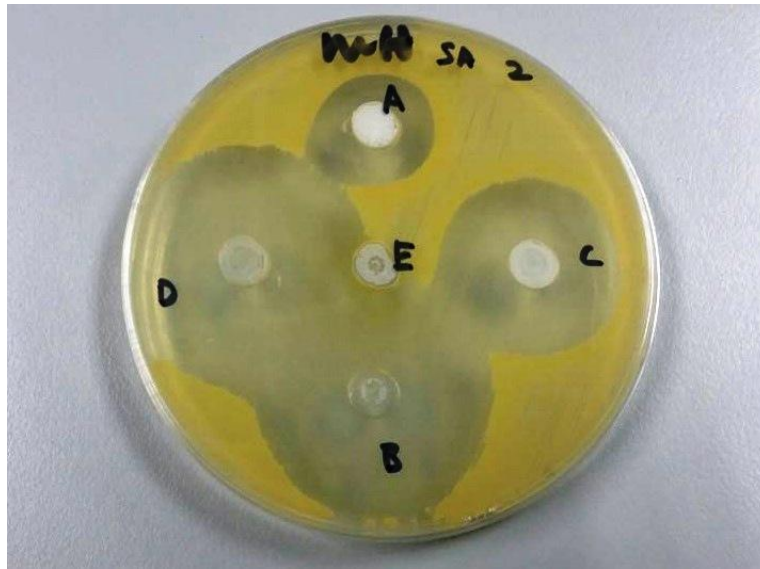


Fig. 1. Bacterial isolates on MHA agar exposed to different toothpaste of same concentrations

3. RESULTS

The composition on the label of the different toothpaste brands used in this study is shown in Table 1. All the toothpaste brands contain the same ingredients which were sodium lauryl sulfate, sorbitol and flavour. Both Colgate-total and Safi brand contain triclosan.

Table 2 shows the inhibition zone (mm) of the various toothpastes used against the test microorganisms. The result revealed that Colgate-Total brand has the highest mean zone of inhibition (Z.O.I) on the test organisms (30.7 mm) followed by Safi brand (29.2 mm) and Tesco brand (12.5 mm), while Mu'min brand showed the least activity on the test micro-organisms

(2.4 mm). Tap water does not show any antibacterial against any of the tested microbial species (Table 2).

Fig. 2 depicts that Mu'min brand toothpaste showed antibacterial activity against *S. aureus* in dose dependent manner. Mu'min brand toothpaste does not possess any antibacterial ingredient against other microorganisms tested. Fig. 3 showed that Colgate-total brand possessed an antibacterial activity against all the tested microbial strains in dose dependent manner. The most prominent activity of Colgate-total brand was against *S. aureus*. Tesco brand toothpaste brand showed antimicrobial effect against some of the tested microorganisms. As depicted in Fig. 4, Tesco brand toothpaste

Table 1. Composition of toothpaste as per stated in the packaging

| Toothpaste | Composition |
|---------------|---|
| Colgate-Total | Sodium fluoride, water, triclosan, sorbitol, hydrated silica, sodium lauryl sulfate, flavor, carrageenan, sodium hydroxide, sodium fluoride, sodium saccharin, triclosan |
| Safi | Dicalcium phosphate dihydrate, water, sorbitol, glycerin, sodium lauryl sulfate, flavour, sodium fluoride, xanthan gum, sodium saccharin, triclosan, tetrasodium pyrophosphate, hydroxyethylcellulose, calcium lactate, piper betle leaf extract, salvadora persica (sugi) bark/root extract. |
| Tesco | Aqua, sorbitol, hydrated silica, glycerin, sodium lauryl sulfate, aroma, cellulose gum, sodium bicarbonate, zinc citrate, sodium fluoride, sodium saccharin, allantoin, hydroxyethylcellulose, limonene, sodium fluoride. |
| Mu'min | Calcium carbonate, water, hydrated silica, sorbitol, glycerin, sodium lauryl sulfate, flavor, dicalcium phosphate dihydrate, cellulose gum, mentha piperita (peppermint) leaf extract, calcium phosphate, sodium saccharin, sodium benzoate, xylitol. |

Table 2. Zone of inhibition (mm) of different toothpastes brand

| Toothpaste brands | Test organism | Z.O.I at 2:5 | Z.O.I at 4:5 | Z.O.I at 100% | Average |
|-------------------|----------------------|--------------------|--------------------|--------------------|------------|
| | | Concentration (mm) | Concentration (mm) | Concentration (mm) | Z.O.I (mm) |
| Mu'min | <i>S. aureus</i> | 17.0 ± 1.4 | 18.0 ± 1.3 | 19.0 ± 1.2 | 12.0 |
| | <i>P. mirabilis</i> | 0.0 ± 0.0 | 0.0 ± 0.0 | 0.0 ± 0.0 | 0.0 |
| | <i>K. pneumoniae</i> | 0.0 ± 0.0 | 0.0 ± 0.0 | 0.0 ± 0.0 | 0.0 |
| | <i>S. typhi</i> | 0.0 ± 0.0 | 0.0 ± 0.0 | 0.0 ± 0.0 | 0.0 |
| | <i>E. coli</i> | 0.0 ± 0.0 | 0.0 ± 0.0 | 0.0 ± 0.0 | 0.0 |
| | | | Mean | 2.4 | |
| Safi | <i>S. aureus</i> | 42.0 ± 1.4* | 40.0 ± 0.0* | 44.0 ± 0.0* | 42.0 |
| | <i>P. mirabilis</i> | 21.0 ± 1.6 | 31.0 ± 2.1* | 30.0 ± 2.2* | 27.3 |
| | <i>K. pneumoniae</i> | 21.0 ± 1.7 | 25.0 ± 2.3 | 28.0 ± 1.8* | 24.7 |
| | <i>S. typhi</i> | 25.0 ± 1.1 | 15.0 ± 1.6 | 31.0 ± 2.0 | 23.7 |
| | <i>E. coli</i> | 27.0 ± 1.2 | 27.0 ± 1.4 | 31.0 ± 2.4 | 28.3 |
| | | | Mean | 29.2 | |
| Tesco | <i>S. aureus</i> | 29.0 ± 1.6* | 27.0 ± 1.4* | 20.0 ± 1.3 | 25.3 |
| | <i>P. mirabilis</i> | 15.0 ± 1.2 | 16.0 ± 1.3 | 16.0 ± 1.2 | 15.7 |
| | <i>K. pneumoniae</i> | 11.0 ± 1.3 | 0.0 ± 0.0 | 0.0 ± 0.0 | 3.7 |
| | <i>S. typhi</i> | 15.0 ± 1.2 | 14.0 ± 1.3 | 0.0 ± 0.0 | 9.7 |
| | <i>E. coli</i> | 13.0 ± 1.3 | 11.0 ± 0.6 | 0.0 ± 0.0 | 8.0 |
| | | | Mean | 12.5 | |
| Colgate-Total | <i>S. aureus</i> | 40.0 ± 2.1* | 42.0 ± 2.4* | 44.0 ± 2.0* | 42.0 |
| | <i>P. mirabilis</i> | 27.0 ± 1.6 | 28.0 ± 1.4 | 30.0 ± 2.1 | 28.3 |
| | <i>K. pneumoniae</i> | 24.0 ± 2.0 | 25.0 ± 1.2 | 29.0 ± 0.0 | 26.0 |
| | <i>S. typhi</i> | 30.0 ± 1.9* | 29.0 ± 1.4* | 31.0 ± 1.8* | 30.0 |
| | <i>E. coli</i> | 27.0 ± 1.7* | 26.0 ± 1.6 | 29.0 ± 1.5* | 27.3 |
| | | | Mean | 30.7 | |
| Tap water | <i>S. aureus</i> | | | 0.0 ± 0.0 | 0.0 |
| | <i>P. mirabilis</i> | | | 0.0 ± 0.0 | 0.0 |
| | <i>K. pneumoniae</i> | | | 0.0 ± 0.0 | 0.0 |
| | <i>S. typhi</i> | | | 0.0 ± 0.0 | 0.0 |
| | <i>E. coli</i> | | | 0.0 ± 0.0 | 0.0 |

Z.O.I; Zone of inhibition; n=3. *p<0.05

brand showed statistically significant antimicrobial against *S. aureus* at 2:5 (Z.O.I of 29 mm). However, the antibacterial activity against *S. aureus* was found to be reduced with the increase in toothpaste concentration (4:5; Z.O.I: 27 mm; 100%; Z.O.I: 20 mm) (Table 2). Fig. 3 also indicated that Tesco brand toothpaste showed the highest Z.O.I at 2:5 as compared to 4.5 mg/ml and 100% against the entire microorganisms tested except *P. mirabilis*. Tesco brand toothpaste showed maximum zone of inhibition against *P. mirabilis* at 4:5 (16 mm) as compared to 2:5 (15 mm). However, there is no increase in antimicrobial effect (Z.O.I; 16 mm) of Tesco brand toothpaste against *P. mirabilis* with the increase in concentration (100%). Safi brand toothpaste also possessed promising antimicrobial activity against the entire tested microorganism especially *S. aureus* with average zone of inhibition of 29.2 mm (Fig. 5).

4. DISCUSSION

The main step towards a healthy and good looking tooth is maintenance of good oral hygiene. A good oral hygiene will prevent growth of microbial species that can eventually cause mouth odour and dental plaque [4]. Hence, there is a massive need to minimize the growth of microorganisms by using antimicrobial agent [8]. In current scenario, there is huge number of companies promoting their toothpaste by claiming the presence of special active ingredients which could protect the teeth against decay. The active ingredients in oral products act by different mechanism to show their bactericidal effect. It may act via disruption of microorganism's cell wall, inhibition of microbial enzyme activity or by slowing multiplication process of microbial species [9]. The well diffusion antimicrobial assay served as an established method to determine antimicrobial

activity of herbs, commercial oral product and cosmetic product [10].

As showed in Fig. 3, Colgate-Total brand toothpaste showed highest inhibition zone in average (30.7 mm) as compared to other toothpaste brand against all the tested microbial with most promising activity against *S. aureus*. The presence of fluoride as the active ingredient in this toothpaste might reduce the number of

streptococcal colony forming unit that is responsible for dental plaque formation [11]. Safi brand toothpaste also possessed promising antimicrobial activity against the entire tested microorganism with average zone of inhibition of 29.2 mm. The presence of triclosan and sodium fluoride in the Colgate-total brand and Safi toothpaste might contribute to the significant antimicrobial activity of Colgate-total and Safi brand toothpaste (Table 1). It was reported that

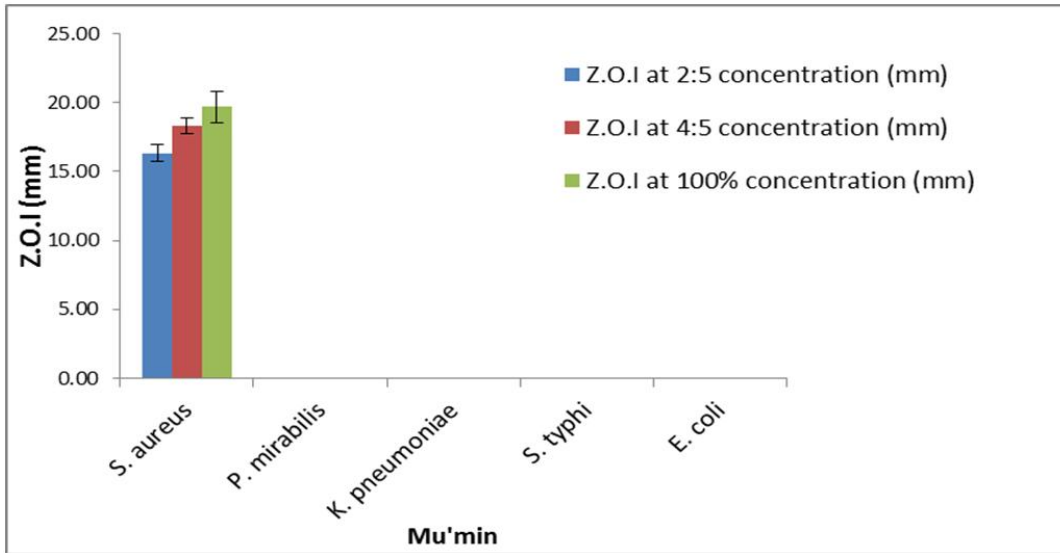


Fig. 2. Zone of inhibition of Mu'min brand toothpaste against microorganisms

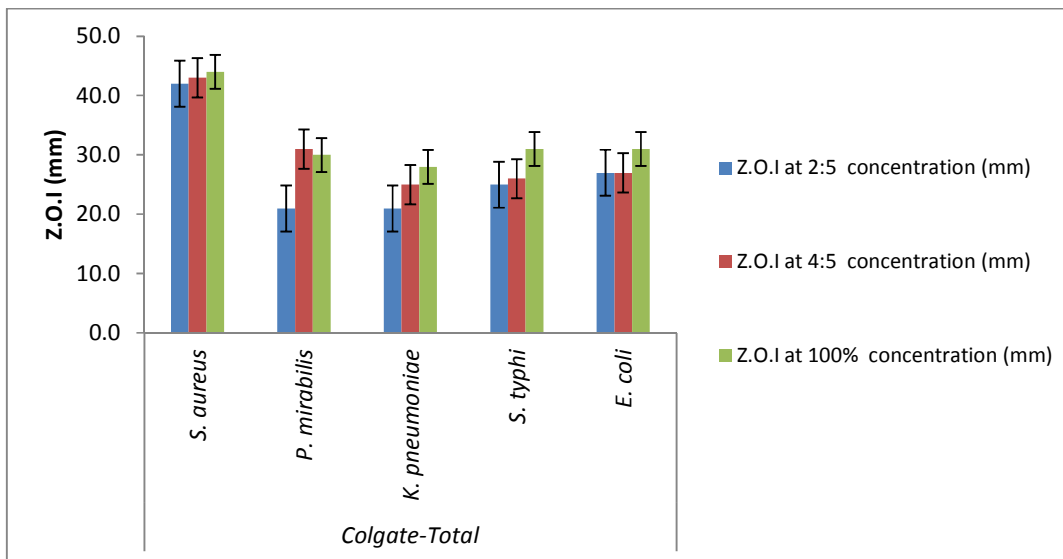


Fig. 3. Zone of inhibition of Colgate-total brand toothpaste against tested microorganisms

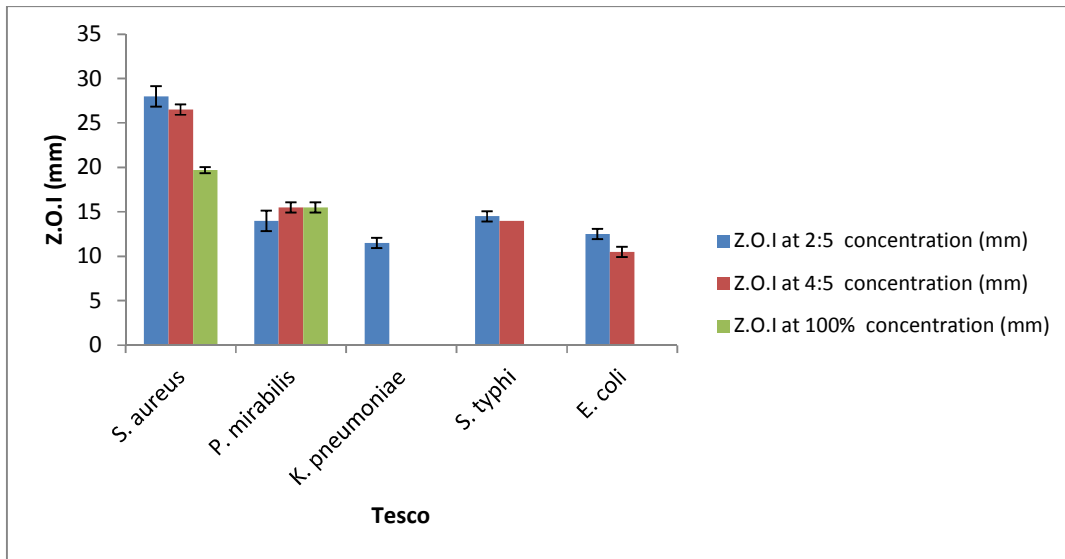


Fig. 4. Zone of inhibition of Tesco brand toothpaste against tested microorganisms

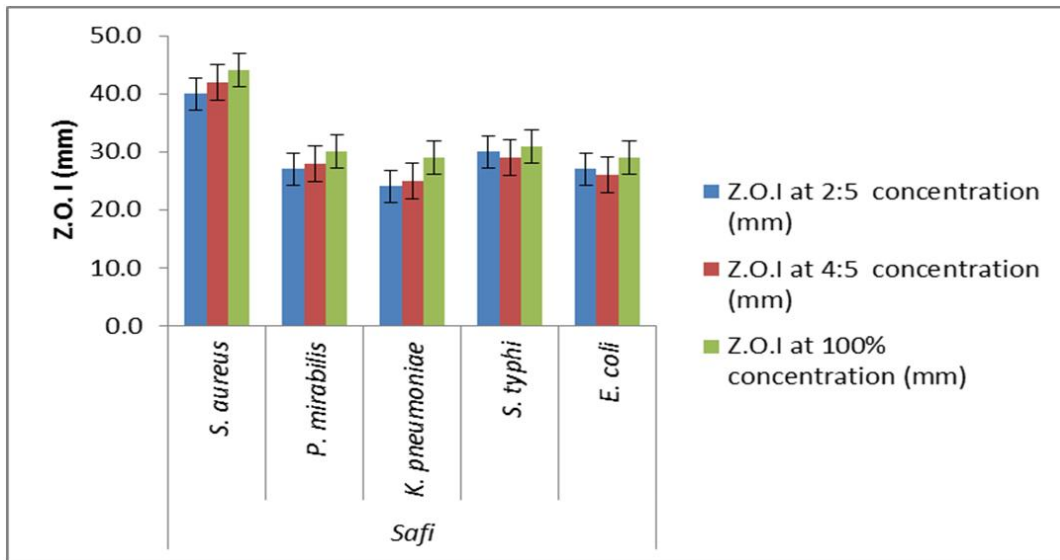


Fig. 5. Zone of inhibition of Safi brand toothpaste against tested microorganisms

triclosan and sodium fluoride could reduce 20% of oral bacteria formation [12]. In addition, triclosan has been used over 30 years in oral hygiene product industry for toothpaste and mouth-rinses formulation due to its antibacterial and antifungal effect [13]. In the present study, it was revealed that the presence of piper beetle leaf extract and *Salvadora persica* (sugi) bark/root extract might promote the antibacterial effect of Safi brand toothpaste, but it is not equally effective as Colgate-Total brand formulation. However, Safi brand toothpaste showed better

antimicrobial effect as compared to Mu'min and Tesco brand toothpaste. This was in accordance with the review data by Moran et al. [14] that indicated the efficacy of herbal toothpaste in reducing plaque formation. Mu'min and Tesco brand toothpastes might have least antimicrobial effect against studied microbial strain due to lack of active ingredients present in its toothpaste formulation.

Fig. 4 indicated that 2:5 mg/mL concentration of Tesco brand toothpaste showed the highest

Z.O.I at 2:5 as compared to 4.5 mg/ml and 100% against the entire microorganisms tested except *P. mirabilis*. This result indicated that the antimicrobial activity of this toothpaste against all the tested microorganisms except *P. mirabilis* is at maximum in diluted form (2:5).

As shown in Table 2, Mu'min brand toothpaste showed the least inhibitory effect (mean Z.O.I; 2.4) against all the tested microorganisms as compared to other brand toothpaste. Mu'min brand toothpaste showed dose dependent zone of inhibition (2:5; 17 mm; 4:5; 18 mm and 100%; 19 mm). There was no significant zone of inhibition recorded for Mu'min brand toothpaste against *P. mirabilis*, *K. pneumoniae*, *S. typhi* and *E. coli*.

5. CONCLUSION

The present work has shown that Colgate-total brand toothpaste was more effective in controlling oral microflora as compared to other brand of toothpaste. This result will provide useful evidence to the public to support the benefit of daily usage of current toothpaste to prevent oral disease.

DISCLAIMER

Mentioning the names of commercial brands or related products do not indicate any endorsement or disapproval of those brands. Using the names of commercial brands in research paper is sole decision of authors of the related paper. Publisher of the journal will always discourage author for naming of these commercial brands in the research article, but if the author insists to mention the names of the product to clarify the advantages and disadvantages of the mentioned products for public welfare then it will be authors' sole decision. Publisher of the journal will not take any responsibility regarding this issue as it is only, the personal decision of the author.

COMPETING INTERESTS

We declare that we have no conflict of interest. This research was not funded by any of the toothpaste companies.

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