RESEARCH PAPER

Assessment and Comparison of Commercial Toothpastes for Their pH and Antibacterial Effect Against Oral Pathogens: An In Vitro Study

K P Sowmya[1], Karthikeyan Murthykumar[2*]

[1] Intern, Department of Periodontics, Saveetha Dental College and Hospitals, SIMATS, Saveetha University, Chennai - 600077, Tamil Nadu, India. Email: sowmya2620palanisamy@gmail.com

[2*] Associate Professor, Department of Periodontics, Saveetha Dental College and Hospitals, SIMATS, Saveetha University, Chennai - 600077, Tamil Nadu, India (Corresponding Author).
Email: karthikeyanmurthykumar@gmail.com

Received: 15th Feb, 2026; **Revised:** 27th Feb, 2026; **Accepted:** 20th Mar, 2026; **Available Online:** 5th Apr, 2026

ABSTRACT

Toothpastes are essential for maintaining oral hygiene by regulating pH and controlling microbial biofilm. Variations in formulation may influence their antibacterial efficacy and protective role against dental caries. To evaluate and compare the pH and antibacterial activity of commercially available toothpastes against common oral pathogens. Seven commercially available toothpastes (IPCA, Parodontax, Colgate White, Cheero, Sensodyne, Apollo Charcoal, and Dabur Charcoal) were analyzed. The pH was measured using a calibrated digital pH meter. Antibacterial activity was assessed using the agar well diffusion method against Streptococcus mutans, Lactobacillus casei, and Actinomyces viscosus. Zones of inhibition (ZOI) were measured in millimeters. All toothpastes exhibited near-neutral pH values ranging from 6.8 to 7.4. Parodontax demonstrated the highest antibacterial activity against all tested organisms, followed by Dabur Charcoal and Apollo Charcoal. Cheero showed minimal antibacterial effect. While all tested toothpastes maintained a safe pH range, significant differences in antibacterial efficacy were observed. Toothpastes containing fluoride and herbal components showed enhanced antimicrobial properties.

Keywords: Toothpaste, pH, Antibacterial activity, Oral pathogens, In vitro study, Dental caries

How to cite this article: Sowmya KP, Murthykumar K. Assessment and Comparison of Commercial Toothpastes for Their pH and Antibacterial Effect Against Oral Pathogens: An In Vitro Study. Int J Drug Deliv Technol. 2026;16(25s): 113-118. DOI: 10.25258/ijddt.16.25s.12

Source of support: Nil.

Conflict of interest: None

1. Introduction

The oral cavity represents a highly complex and dynamic microbial ecosystem that harbors a diverse range of microorganisms, including bacteria, fungi, and viruses. Under physiological conditions, these microorganisms exist in a balanced state, contributing to oral homeostasis(Alavi et al. 2025). However, disruption of this equilibrium—often due to inadequate oral hygiene, dietary habits, or host-related factors—leads to the formation of dental plaque, a structured microbial biofilm that adheres to tooth surfaces. This biofilm plays a central role in the pathogenesis of dental caries and periodontal diseases, which remain among the most prevalent chronic conditions worldwide. Dental caries is a multifactorial disease primarily driven by acidogenic and aciduric bacteria(Hu et al. 2026). Among these, Streptococcus mutans is recognized as a key initiator due to its ability to metabolize fermentable carbohydrates into organic acids, resulting in a localized drop in pH and subsequent enamel demineralization(Yadav et al. 2026). In addition to initiation, the progression of carious lesions is strongly associated with species such as Lactobacillus casei, which thrive in low pH environments and contribute to continued mineral loss. Furthermore, Actinomyces viscosus is implicated in root surface caries and early plaque formation, particularly in areas of gingival recession. The persistence and activity of these

microorganisms underscore the importance of effective antimicrobial strategies in daily oral care(Xiong et al. 2022)(Ji et al. 2025).

Toothpastes (dentifrices) are among the most widely used oral hygiene products and serve as a primary preventive measure against dental diseases. Their effectiveness is not only based on mechanical plaque removal through brushing but also on the chemical properties of their constituents(Das et al. 2025). Modern toothpaste formulations typically include abrasives, humectants, detergents, flavoring agents, and active therapeutic ingredients such as fluoride and antimicrobial agents(Banic Vidal et al. 2025). Fluoride, in particular, plays a pivotal role in caries prevention by enhancing remineralization, inhibiting demineralization, and interfering with bacterial metabolic pathways(Sureendar et al. 2025). In recent years, there has also been increasing interest in herbal and natural formulations, which incorporate plant-derived compounds with reported antimicrobial and anti-inflammatory properties(Sridharan et al. 2025). An important physicochemical parameter influencing the efficacy and safety of toothpastes is their pH. The critical pH for enamel dissolution is approximately 5.5, below which hydroxyapatite crystals begin to break down, leading to demineralization(Ji et al. 2025; Tsilingaridis et al. 2026). Therefore, maintaining a neutral or slightly alkaline pH is essential for preserving enamel integrity and supporting remineralization processes. In addition, the pH of dentifrices may influence the activity of their active ingredients, including fluoride and antimicrobial agents, thereby affecting their overall performance(Randorn et al. 2026).

Despite the wide range of commercially available toothpastes, significant variations exist in their composition, active ingredients, and claimed therapeutic benefits. These differences may result in variability in their antibacterial efficacy and pH characteristics(Fernandes et al. 2022)(Kengadaran et al. 2022). While many products are marketed based on specific benefits such as whitening, sensitivity relief, or herbal content, there is a need for scientific evaluation of their actual performance against oral pathogens(Kováč et al. 2022). The present in vitro study was designed to assess and compare the pH and antibacterial activity of selected commercially available toothpastes against common oral pathogens, namely Streptococcus mutans, Lactobacillus casei, and Actinomyces viscosus(Sridharan et al. 2025; Duraisamy et al. 2024). By evaluating these parameters, the study aims to provide evidence-based insights into the effectiveness of different toothpaste formulations, thereby aiding clinicians and consumers in making informed choices for optimal oral health maintenance.

2. Materials and methods

This in vitro experimental study was conducted to evaluate the pH and antibacterial efficacy of seven commercially available toothpaste brands.

2.1. Sample Selection

The following toothpaste brands were selected

Fig.1. Toothpaste brands (A) IPCA (B) Paradontax (C) Colgate white (D) Cheero (E) Sensodyne (F) Apollo charcoal (G) Dabur charcoal

These brands were chosen based on their availability and varied formulations, including fluoride-based compositions.

The antibacterial activity was tested against the following oral pathogens:

- Streptococcus mutans
- Lactobacillus casei
- Actinomyces viscosus

These microorganisms were selected due to their established role in dental caries and plaque formation.

2.2. Preparation of Toothpaste Samples and pH Measurement

Each toothpaste sample was diluted in sterile distilled water to obtain a uniform consistency suitable for testing. Standardized concentrations were maintained to ensure comparability.The pH of each toothpaste was measured using a calibrated digital pH meter. Measurements were taken in triplicate, and the mean value was recorded.

2.3. Antibacterial Testing: Agar Well Diffusion Method

The antibacterial activity of the selected toothpastes was evaluated using the agar well diffusion method. Sterile agar plates were first prepared and uniformly inoculated with the respective bacterial cultures to

ensure consistent microbial growth. Using a sterile borer, wells of standard diameter were carefully created in the agar medium. The prepared toothpaste samples were then introduced into these wells under aseptic conditions. Following sample application, the plates were incubated at 37°C for a period of 24 hours to allow for adequate bacterial growth and interaction with the test materials. After incubation, the antibacterial efficacy of each toothpaste was determined by measuring the zones of inhibition surrounding the wells, expressed in millimeters, which indicated the extent of microbial growth suppression.

2.4. Data Analysis

The results were analyzed by comparing the mean zone of inhibition for each toothpaste against each microorganism. Statistical comparisons were made descriptively.

3. Results

3.1. pH Analysis

Observed pH Values (Mean ± SD):

- IPCA: 7.36 ± 0.05
- Parodontax: 7.33 ± 0.05
- Colgate White: 6.8 ± 0.1
- Cheero: 7.16 ± 0.5
- Sensodyne: 7.4 ± 0.1
- Apollo Charcoal: 7.1 ± 0.1
- Dabur Charcoal: 7.2 ± 0.1

All tested toothpastes exhibited near-neutral pH values, ranging from 6.8 to 7.4. Sensodyne showed the highest pH (7.4), while Colgate White had the lowest (6.8). Importantly, none of the toothpastes fell below the critical pH threshold of 5.5, indicating safety in terms of enamel demineralization.

3.2. Antibacterial Activity

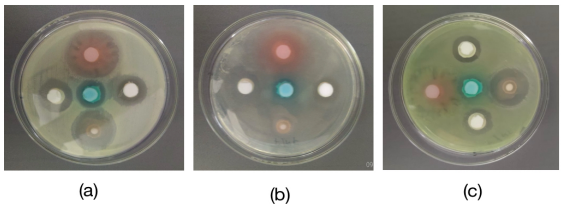

Fig.2. Anti-bacterial activity of toothpaste against (a) Streptococcus mutans (b) Lactobacillus casei (c) Actinomycetes viscosus

3.2.1 Against Streptococcus mutans

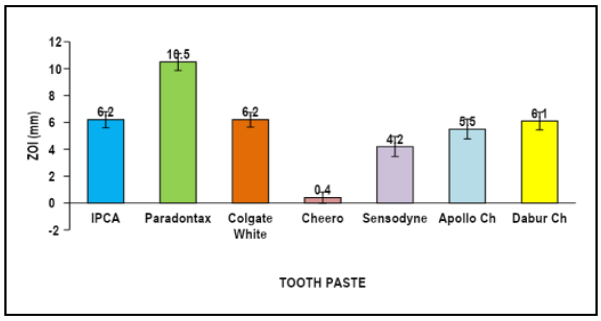

Fig.3. X axis shows different brands of toothpaste and Y axis shows zone of inhibition against S. mutans

Parodontax demonstrated the highest antibacterial activity, exhibiting the largest zone of inhibition (approximately 10.5 mm) among all the tested toothpastes. Dabur Charcoal and Apollo Charcoal also showed considerable antibacterial effects, indicating moderate efficacy against the tested oral pathogens. In contrast, Cheero exhibited minimal activity, reflecting a comparatively lower ability to inhibit bacterial growth.

3.2.2 Against Lactobacillus casei

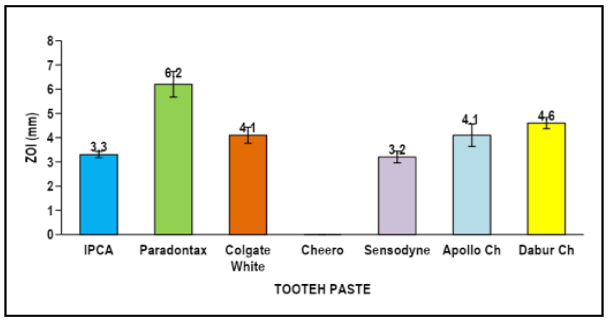

Fig.4. X axis shows different brands of toothpaste and Y axis shows zone of inhibition against L. casei

Parodontax again exhibited the highest antibacterial activity, showing a zone of inhibition of approximately 6.2 mm. Dabur Charcoal demonstrated moderate inhibitory effects against the tested organism, indicating a fair level of antibacterial efficacy. In contrast, Cheero showed a negligible effect, suggesting minimal ability to inhibit bacterial growth under the study conditions.

3.2.3 Against Actinomyces viscosus

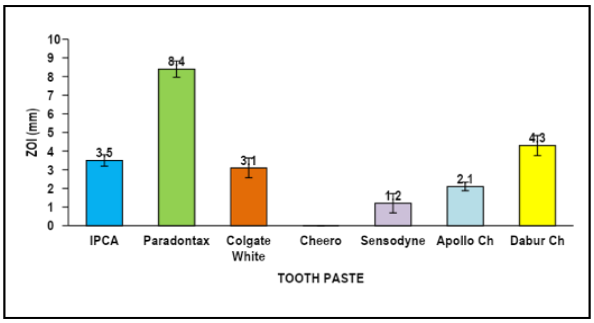

Fig.5. X axis shows different brands of toothpaste and Y axis shows zone of inhibition against A. viscosus

Parodontax demonstrated the highest antibacterial activity, with a zone of inhibition of approximately 8.4 mm. Dabur Charcoal exhibited moderate activity against the tested organism, indicating a reasonable level of antibacterial effectiveness. In contrast, Cheero showed a very low antibacterial effect, suggesting limited ability to inhibit bacterial growth under the experimental conditions.

4. Discussion

The present in vitro study demonstrated that while all tested toothpastes maintained a near-neutral pH (6.8–7.4), ensuring safety against enamel demineralization, their antibacterial efficacy varied considerably against Streptococcus mutans(Abram et al. 2022)(Reddy et al. 2026), Lactobacillus casei, and Actinomyces viscosus. The findings indicate that pH alone does not determine antimicrobial effectiveness, as toothpastes with similar pH values showed different inhibitory actions(Takeuchi-Hatanaka et al. 2025). Among the tested formulations, Parodontax consistently exhibited the highest antibacterial activity, which may be attributed to its combination of active ingredients, including herbal extracts known for their antimicrobial properties(Lee et al. 2025). Fluoride-containing toothpastes also demonstrated notable antibacterial effects, supporting previous evidence that fluoride interferes with bacterial metabolism and acid production(Hassan et al. 2021). Charcoal-based toothpastes showed moderate efficacy, suggesting that their role may be supportive rather than primary in antimicrobial action(Adeleye et al. 2021). The comparatively low activity observed in some toothpastes highlights the importance of formulation and concentration of active agents. Although the results are consistent with previous studies reporting variability in dentifrice efficacy, the in vitro nature of the study limits direct clinical extrapolation(Reddy et al. 2026; Gunasekaran and Sathishkumar 2026). Overall, the findings emphasize that toothpaste selection should consider antimicrobial properties and formulation composition rather than relying solely on pH or brand preference(Sadeghi-Nejad et al. 2018).

5. Conclusion

Within the limitations of this in vitro study, all tested toothpastes exhibited pH values within a safe range, indicating minimal risk for enamel demineralization. However, significant differences were observed in their antibacterial activity against common oral pathogens. Parodontax demonstrated the highest antimicrobial efficacy, followed by charcoal-based and fluoride-containing formulations. These findings suggest that toothpaste composition plays a crucial role in determining its effectiveness in controlling oral microorganisms. Therefore, selecting a toothpaste with proven antibacterial properties, along with maintaining proper oral hygiene practices, is essential for the prevention of dental caries and periodontal diseases.

References

Abram, Amber M., Michelle M. Szewczyk, Seon G. Park, et al. 2022. "A Co-Association of Streptococcus Mutans and Veillonella Parvula/dispar in Root Caries Patients and Biofilms." *Infection and Immunity* 90 (10): e0035522.

Adeleye, Olutayo Ademola, Oluyemisi Bamiro, Mark Akpotu, Modupe Adebowale, John Daodu, and Mariam Adeola Sodeinde. 2021. "Physicochemical Evaluation and Antibacterial Activity of Herbal Toothpaste." *Turkish Journal of Pharmaceutical Sciences* 18 (4): 476–482.

Alavi, Seyed Ebrahim, Hasan Ebrahimi Shahmabadi, Lavanya A. Sharma, and Ajay Sharma. 2025. "The Role of the Oral Microbiome in Periodontal Disease: A Systematic Review of Microbial Associations and Therapeutic Implications." *Current Microbiology* 83 (1): 64.

Banic Vidal, Llubitza Slaviza, Ivan Šalinović, Nikolina Nika Veček, Anja Ivica, Ivana Miletić, and Silvana Jukić Krmek. 2025. "Fluoride Uptake and Surface Characteristics of Ion-Releasing Restoratives After Brushing with Fluoride Toothpastes." *Materials (Basel, Switzerland)* 18 (9). https://doi.org/10.3390/ma18092152.

Das, Ayesh, Jayashri Prabakar, I. Meignana Arumugham, S. Rajeshkumar, Jayasree Anandan, and Amal Siby. 2025. "Polydopamine-Infused

Toothpaste: An in Vitro Assessment of Cytotoxicity and Embryonic Toxicology." *Journal of Oral Biology and Craniofacial Research* 15 (6): 1448–1453.

Duraisamy, Revathi, Dhanraj Ganapathy, Rajeshkumar Shanmugam, Ezhilarasan Devaraj, and Amrutha Shenoy. 2024. "Assessment of Antimicrobial Activity of Nanocomposites Based on Nano-Hydroxyapatite (HAP), Chitosan, and Vitamin K2." *Cureus* 16 (1): e53339.

Fernandes, Nayanna Lana Soares, José Gabriel Victor Costa Silva, Elizabeth Barreto Galvão de Sousa, et al. 2022. "Effectiveness of Fluoride-Containing Toothpastes Associated with Different Technologies to Remineralize Enamel after pH Cycling: An in Vitro Study." *BMC Oral Health* 22 (1): 489.

Gunasekaran, Vinothini, and Palanivel Sathishkumar. 2026. "Possible Applicability of Flavonoids as a Natural Drug in Real World Dentistry: A Simple and Biocompatible Approach." *Natural Product Research* 40 (4): 1145–1146.

Hassan, M., F. Shafique, H. Bhutta, et al. 2021. "A Comparative Study to Evaluate the Effects of Antibiotics, Plant Extracts and Fluoride-Based Toothpaste on the Oral Pathogens Isolated from Patients with Gum Diseases in Pakistan." *Brazilian Journal of Biology = Revista Brasleira de Biologia* 83 (July): e242703.

Hu, Lingxi, Jing Chen, Chun Hung Chu, et al. 2026. "pH-Driven Progression: Dental Caries to Pulpal and Periapical Disorders." *Archives of Oral Biology* 186 (March): 106574.

Ji, Mengzhen, Kaixin Xiong, Di Fu, et al. 2025. "The Landscape of the Microbiome at Different Stages of Root Caries." *Clinical Oral Investigations* 29 (4): 217.

Kengadaran, Shivashankar, Divvi Anusha, Kavya Baskar, Kavitha Muthukrishnan, J. Pooraninagalakshmi, and Jayashri Prabakar. 2022. "Comparative Effectiveness of Herbal and Conventional Toothpaste on Prevention of Dental Caries: Systematic Review and Meta-Analysis." *Indian Journal of Dental Research : Official Publication of Indian Society for Dental Research* 33 (3): 332–337.

Kováč, Ján, Lívia Slobodníková, Eva Trajčíková, et al. 2022. "Therapeutic Potential of Flavonoids and Tannins in Management of Oral Infectious Diseases-A Review." *Molecules (Basel, Switzerland)* 28 (1). https://doi.org/10.3390/molecules28010158.

Lee, Jaewoong, Woo-Ri Shin, Yang-Hoon Kim, Ji-Young Ahn, Soryong Chae, and Jiho Min. 2025. "Targeted Inhibition of Oral Biofilm Formation Using Phage-Derived High-Affinity Peptides." *Journal of Biotechnology* 402 (June): 51–58.

Randorn, Chamnan, Pongpen Kaewdee, Gobwute Rujijanagul, and Sujitra Tandorn. 2026. "A Qualitative In Vitro SEM Study on the Protective Effects of a Self-Antibacterial Nano-Hydroxyapatite Toothpaste Against Acid-Induced Enamel Surface Erosion." *International Journal of Molecular Sciences* 27 (6). https://doi.org/10.3390/ijms27062796.

Reddy, Chevuru Sai Shreya, Lekha Sree Venkatesan, Dhanraj Ganapathy, and Palanivel Sathishkumar. 2026. "Prevalence and Eradication of Mixed Biofilms of Streptococcus Mutans and Candida Albicans Using Naringin: In Vitro and in Silico Investigations." *Archives of Oral Biology* 183 (March): 106482.

Sadeghi-Nejad, Batool, Eskandar Moghimipour, Sedigheh Yusef Naanaie, and Shahrzad Nezarat. 2018. "Antifungal and Antibacterial Activities of Polyherbal Toothpaste against Oral Pathogens, in." *Current Medical Mycology* 4 (2): 21–26.

Sridharan, Gokul, Surendar Balu, Raji Atchudan, et al. 2025. "Electrochemical Detection of Diclofenac and Clindamycin Using ZnO nanorods/RGO Nanocomposite Modified Electrode." *RSC Advances* 15 (57): 49094–49108.

Sureendar, Bhavesh, Vinothini Gunasekaran, Dhanraj Ganapathy, and Palanivel Sathishkumar. 2025. "Possible Applicability of Flavonoid Hesperetin for the Treatment of Dental Biofilm-Forming." *Journal of Oral Biology and Craniofacial Research* 15 (6): 1799–1805.

Takeuchi-Hatanaka, Kazu, Masahiro Ito, Yoshihiro Hayashi, et al. 2025. "Clinical and Microbiological Effects of a Propolis Toothpaste in Patients with Periodontitis under Supportive Periodontal Therapy: A Randomized Double-Blind Clinical Trial." *Clinical Oral Investigations* 29 (8): 379.

Tsilingaridis, Georgios, Nitesh Tewari, Kyriaki Seremidi, William Papaioannou, and Rodrigo López. 2026. "Dental Biofilm-Induced Gingivitis

in Children and Adolescents Without Known Systemic Involvement: A Systematic Review." *Journal of Clinical Periodontology*, ahead of print, March 29. https://doi.org/10.1111/jcpe.70122.

Xiong, Kaixin, Hualing Zhu, Yanyao Li, et al. 2022. "The Arginine Biosynthesis Pathway of Candida Albicans Regulates Its Cross-Kingdom Interaction with Actinomyces Viscosus to Promote Root Caries." *Microbiology Spectrum* 10 (4): e0078222.

Yadav, Aparna, Swetha Rajendra, Jyostna Seemala, and Deepika Vajrala. 2026. "Effect of Dental Caries on Oral Health-Related Quality of Life Among Young Adults: A Systematic Review." *Cureus* 18 (3): e104744.