World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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# Evaluation of Experimental Toothpastes Based on *Aloe schweinfurthii* and Fluoride: Antibacterial Activity Against *Streptococcus mutans* and *Aggregatibacter actinomycetemcomitans*

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World Journal of Advanced Research and Reviews, 2026, 29(02), 1121-1125

Publication history: Received on 10 January 2026; revised on 18 February 2026; accepted on 20 February 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.29.2.0422

## Abstract

**Introduction**: oral and dental pathologies, particularly dental caries and gingivitis, remain a major global public health concern. This study aimed to evaluate *in vitro* the antibacterial activity of lyophilized *Aloe schweinfurthii* gel and experimental toothpastes formulated with this gel and/or fluoride against *Streptococcus mutans* and *Aggregatibacter actinomycetemcomitans*.

**Methodology**: Oral samples were collected from adolescents aged 10–19 years presenting with caries and/or gingivitis. Isolated bacteria were tested using disk diffusion and broth microdilution methods to determine inhibition zone diameters (IZD), minimum inhibitory concentrations (MIC), and minimum bactericidal concentrations (MBC).

**Results**: Lyophilized *A. schweinfurthii* gel showed notable antibacterial activity against both strains, with larger inhibition zones at moderate dilutions and an MBC/MIC ratio of 1, confirming a bactericidal effect. Among the experimental toothpastes, the formulation combining gel and fluoride (DC) demonstrated the highest antibacterial efficacy, often superior or comparable to a commercial reference toothpaste.

**Conclusion**: These findings confirm the antibacterial potential of metabolites contained in *Aloe schweinfurthii* gel and suggest a possible synergistic effect with fluoride in the prevention of caries and gingival pathologies. Incorporating this gel into experimental toothpastes represents a promising natural alternative for the prevention of caries and gum disease.

**Keywords:** *Aloe Schweinfurthii*; Lyophilized Gel; Experimental Toothpaste; Antibacterial Activity; *Streptococcus mutans; Aggregatibacter actinomycetemcomitans*

## 1. Introduction

The oral cavity harbors a complex microbiota, whose balance is essential for maintaining oral health. Repeated disruptions, often linked to inadequate lifestyle habits, promote the development of preventable oral pathologies such as tooth decay and periodontal disease, which affect billions of people worldwide [1,3]. Since 2023, the World Health Organization has recommended integrating oral diseases into non-communicable disease (NCD) strategies to unify

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prevention approaches [2]. Epidemiological data show high regional prevalence, particularly in Africa and Cameroon [4,5].

Although regular tooth brushing with fluoridated toothpaste can prevent these conditions [6], studies conducted in African settings indicate that mere possession of oral hygiene tools is insufficient to effectively reduce the prevalence of gingivitis and caries [7–9].

Complementary approaches, including the use of medicinal plant extracts with antibacterial activity, have been explored to strengthen prevention strategies [6,7]. Among these plants, *Aloe*, particularly *Aloe schweinfurthii*, is traditionally used for its antimicrobial properties but remains insufficiently studied in clinical dentistry [8,9].

This study aimed to determine the antibacterial activity of lyophilized *Aloe schweinfurthii* gel and experimental toothpaste formulations containing this gel and/or fluoride against *Streptococcus mutans* and *Aggregatibacter actinomycetemcomitans*.

## 2. Materials and Methods

### 2.1. Study Design and Sites

- Study type: Experimental study.
- Study sites:
  - Yaounde University Teaching Hospital (YUTH): clinical consultations and sampling.
  - Center for the Study and Control of Communicable Diseases: bacterial cultures and antibacterial testing.
  - Galenic Pharmacy Laboratory, Faculty of Medicine and Biomedical Sciences (FMSB), University of Yaounde I: formulation of experimental toothpastes.

### 2.2. Study Population

- Target population: Adolescents aged 10–19 years presenting with caries and/or gingivitis.
- Sampling method: Consecutive sampling of patients attending consultations.
- Inclusion criteria: Participant assent and parental consent; absence of chronic systemic disease.
- Exclusion criteria: Tooth brushing or use of mouthwash within two hours prior to sampling.

### 2.3. Materials

- Plant material: Lyophilized *Aloe schweinfurthii* gel.
- Toothpaste formulations: Sorbitol, sodium lauryl sulfate (SLS), Aloe gel, fluoride (depending on formulation), mint flavoring, pH regulators, preservatives; packaged in sterile 50 g tubes.
- Microbiological materials: Strains of *S. mutans* and *A. actinomycetemcomitans*, Columbia agar, Mueller-Hinton broth, incubators, micropipettes, vortex mixer, antibiotic disks.
- Clinical materials: Dental mirrors, periodontal probes, gloves, masks, hydroalcoholic gel.

### 2.4. Experimental Procedures

- Sampling: Performed before meals and brushing; saliva samples were collected from carious lesions and subgingival fluid.
- Bacterial culture and identification: Cultivation on Columbia agar supplemented with blood; incubation at 37°C for 48 hours; biochemical tests (Gram staining, catalase, oxidase, API 20E).
- Gel sensitivity testing: Disk diffusion method; broth microdilution to determine MIC and MBC; calculation of MBC/MIC ratios.
- Toothpaste formulation: Adjustment of proportions, incorporation of active ingredients, packaging.
- Evaluation of toothpastes: Same protocol as gel testing, at concentrations of 100%, 50%, and 33.3%.

### 2.5. Statistical Analysis

Results were expressed as mean ± 95% confidence interval. Group comparisons were performed using Student's t-test and ANOVA followed by Tukey-Kramer post hoc test, using SPSS version 23.

### 2.6. Ethical Considerations

This study was approved by the Ethics Committee of the Faculty of Medicine and Biomedical Sciences, University of Yaounde I, and authorized by the Yaounde University Teaching Hospital. Parental consent and participant assent were obtained.

## 3. Results

### 3.1. Lyophilized Aloe schweinfurthii Gel

*3.1.1. Bacterial Identification*

Table 1 summarizes the morphological, microscopic, and biochemical characteristics of the isolated bacteria *Streptococcus mutans* and *Aggregatibacter actinomycetemcomitans*.

**Table 1** Characteristics of Isolated Bacteria

| Strain | Colony Morphology | Microscopy | Biochemical Tests | Identification |
|---|---|---|---|---|
| 1 | Round, white colonies | Gram-positive cocci in chains | Catalase-, Oxidase-, Indole-, Mannitol+, Sorbitol+ | *Streptococcus mutans* |
| 2 | Round, white colonies | Gram-negative coccobacillus | Catalase+, Oxidase+, Indole- | *Aggregatibacter actinomycetemcomitans* |

Inhibition Zone Diameters (IZD)

Lyophilized *A. schweinfurthii* gel showed notable bactericidal antibacterial activity against *S. mutans* (Sm) and *A. actinomycetemcomitans* (Aa), with optimal diffusion at moderate dilutions (Table II).

**Table 2** Antibacterial Activity of Lyophilized *A. schweinfurthii* Gel

| Bacteria | C1 (50%) | C2 (33.33%) |
|---|---|---|
| Aa | 25.66 mm | 31.00 mm |
| Sm | 26.00 mm | 30.66 mm |

The MBC/MIC ratio was equal to 1, confirming a bactericidal effect.

### 3.2. Experimental Toothpastes

The DC toothpaste demonstrated inhibition zones similar to those observed for *S. mutans* and superior effects against *A. actinomycetemcomitans* at certain concentrations, suggesting potential effectiveness comparable to commercial toothpastes. Experimental toothpastes showed pH values compatible with oral safety and MBC/MIC ratios ≤ 3.5, confirming bactericidal activity. Table III shows the composition and antibacterial activity of experimental toothpastes

**Table 3** Composition and Antibacterial Activity of Experimental Toothpastes

| Formula | Key Ingredients | Maximum IZD | pH | MBC/MIC Ratio |
|---|---|---|---|---|
| DC (optimal) | Aloe + fluoride, sorbitol 25%, SLS 2%, mint 4% | High at all concentrations | 10.4 | ≤ 3.5 |
| DA | Aloe alone | Lower IZD | – | ≤ 3.5 |
| DF | Fluoride alone | Intermediate IZD | – | ≤ 3.5 |
| P | Parodontax | High IZD | – | ≤ 5 |

## 4. Discussion

### 4.1. Study Limitations

The main limitations of this study relate to the technical requirements for isolating anaerobic bacteria and the limited number of published studies on *Aloe schweinfurthii*, which restricts direct comparison with existing literature.

### 4.2. Antibacterial Activity of Lyophilized *Aloe schweinfurthii* Gel

The inhibition zones obtained indicate that antibacterial activity increased with dilution, possibly due to improved diffusion or release of active compounds. Previous studies on *Aloe vera* extracts demonstrated measurable antibacterial activity against *S. mutans* and *A. actinomycetemcomitans*.

Recent studies on *Aloe schweinfurthii* leaf extracts showed significant inhibition zones against phytopathogenic bacteria, sometimes exceeding those of *Aloe vera*. Furthermore, 2025 findings confirmed an MBC/MIC ratio < 4, indicating bactericidal activity against a wide range of oral bacteria.

### 4.3. Antibacterial Activity of Experimental Toothpastes

Among the tested formulations, the combined Aloe–fluoride toothpaste (DC) showed the highest antibacterial efficacy, especially at diluted concentrations. The association of Aloe gel and fluoride may induce antibacterial synergy, combining plant metabolite inhibition with fluoride's anticariogenic action.

Studies on Aloe-based tooth gels have reported efficacy comparable to conventional commercial toothpastes. The comparison with Parodontax showed similar inhibition against *S. mutans* and superior activity against *A. actinomycetemcomitans* at certain concentrations.

## 5. Conclusion

Lyophilized *Aloe schweinfurthii* gel demonstrated significant antibacterial activity against *Aggregatibacter actinomycetemcomitans* and *Streptococcus mutans*, enhanced at moderate dilutions. Experimental toothpastes formulated with this gel, particularly the Aloe–fluoride combination (DC), exhibited confirmed bactericidal efficacy (MBC/MIC ≤ 3.5). These findings support the integration of *Aloe schweinfurthii* into toothpaste formulations for the prevention of caries and gingival pathologies.

## Compliance with ethical standards

### *Acknowledgments*

The authors sincerely thank the staff of the Yaounde University Teaching Hospital for their collaboration during clinical sampling, as well as the team of the Center for the Study and Control of Communicable Diseases for technical support in microbiological analyses. We also acknowledge the Galenic Pharmacy Laboratory of the Faculty of Medicine and Biomedical Sciences, University of Yaounde I, for assistance in toothpaste formulation. Finally, we thank the participants and their parents for their cooperation.

### *Disclosure of conflict of interest*

The authors declare no conflict of interest related to this study. No external funding influenced the design, execution, analysis, or publication of this work.

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