The Compatible of Chlorhexidine and Toothpaste Formulations in Single-use Oral Care Sets Enhance an Effectiveness on Ventilator-Associated Pneumonia Prevention

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INTRODUCTION

Chlorhexidine gluconate (CHG) is a cationic disinfectant. The positive charge of CHG molecules binds to phospholipids negative charge in bacterial cell walls, causing membrane disruption. CHG is widely used in oral care and infection prevention, including reducing ventilator-associated pneumonia (VAP). However, interactions with anionic or non-ionic surfactants in commercial toothpaste may reduce its effectiveness, highlighting the need for compatible formulations in standardized oral care protocols.

OBJECTIVES

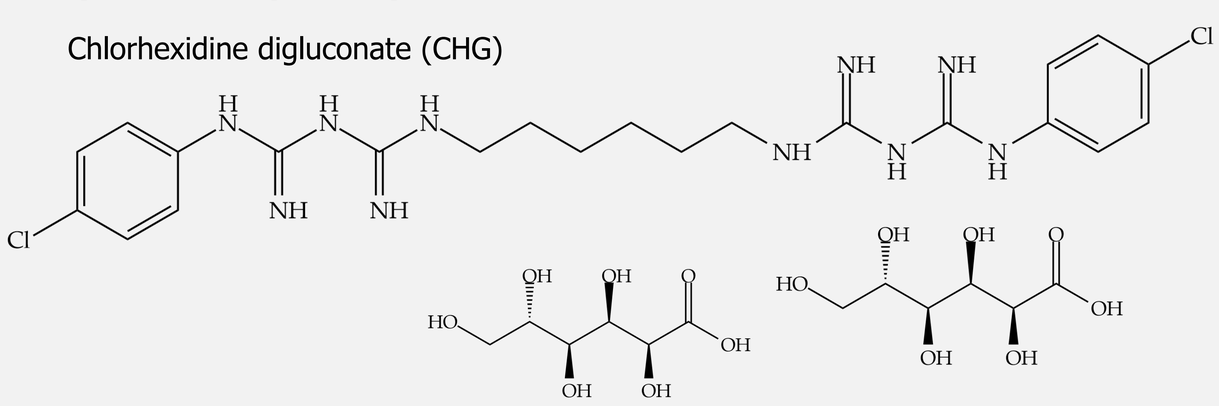
Investigated in vitro kinetic incompatibilities (physical, chemical, and therapeutic) between seven commercial and two developed toothpastes mixed with 0.2% w/v chlorhexidine gluconate (CHG). The compatible formulation was selected for single-use oral care sets and then evaluate the effectiveness in reducing VAP among ICU patients.

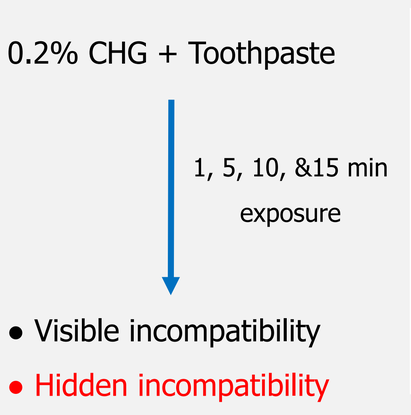
METHODOLOGY

1. **Physical Incompatibility**
   Tested at **1-, 5-, 10-, and 15-min exposure times**.
   Observed by the naked eye for visible changes.
2. **Chemical Incompatibility**
   Determined using **High Performance Liquid Chromatography (HPLC)**.
3. **Therapeutic Incompatibility**
   Evaluated by **antibacterial activity** against
   - *Staphylococcus aureus* ATCC 25923
   - *Escherichia coli* ATCC 25922
4. **Clinical Application**
   The **compatible toothpaste–CHG combination** was developed into **single-use oral care sets** and used for **oral cavity cleaning** following a **standardized oral care protocol** in ICUs across **14 tertiary care hospitals**.

RESULTS

1. Physical Incompatibility





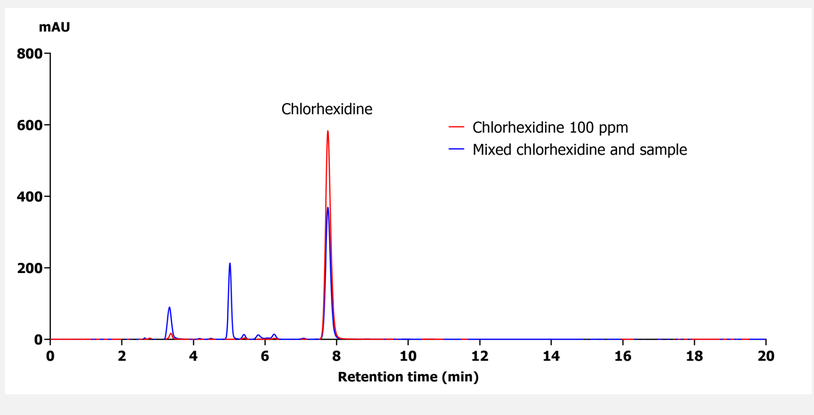


Figure 1. HPLC chromatogram of standard CHG and mixed CHG with toothpaste sample

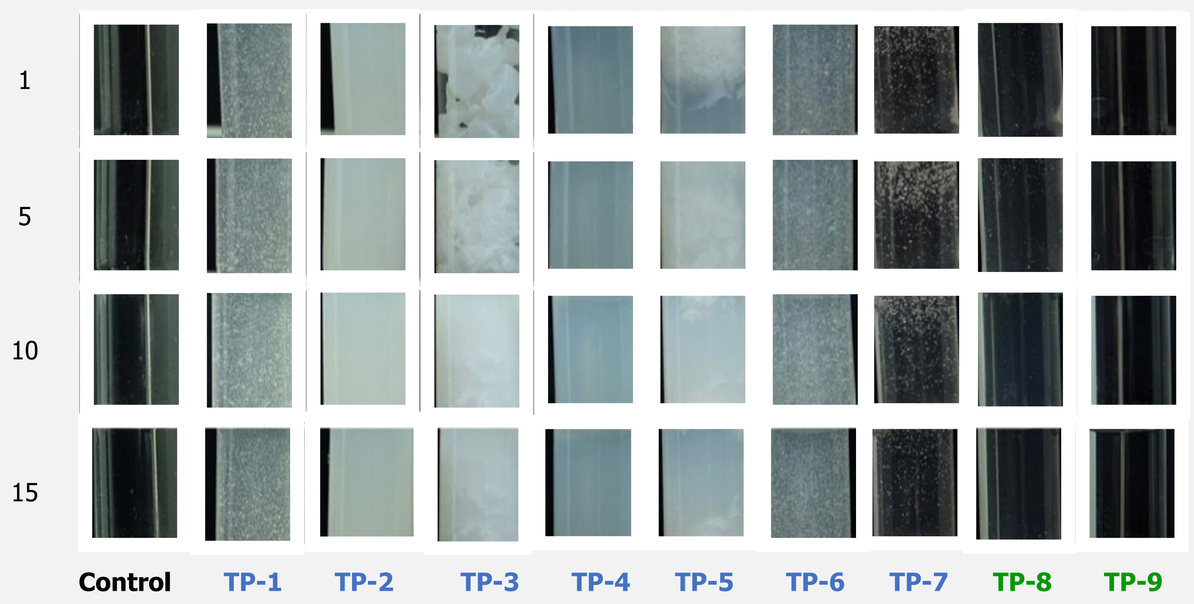


Figure 2. Physical incompatibility of toothpaste samples exposed to CHG for (A) 1, (B) 5, (C) 10, and (D) 15 min, respectively.

RESULTS

2. Chemical Incompatibility

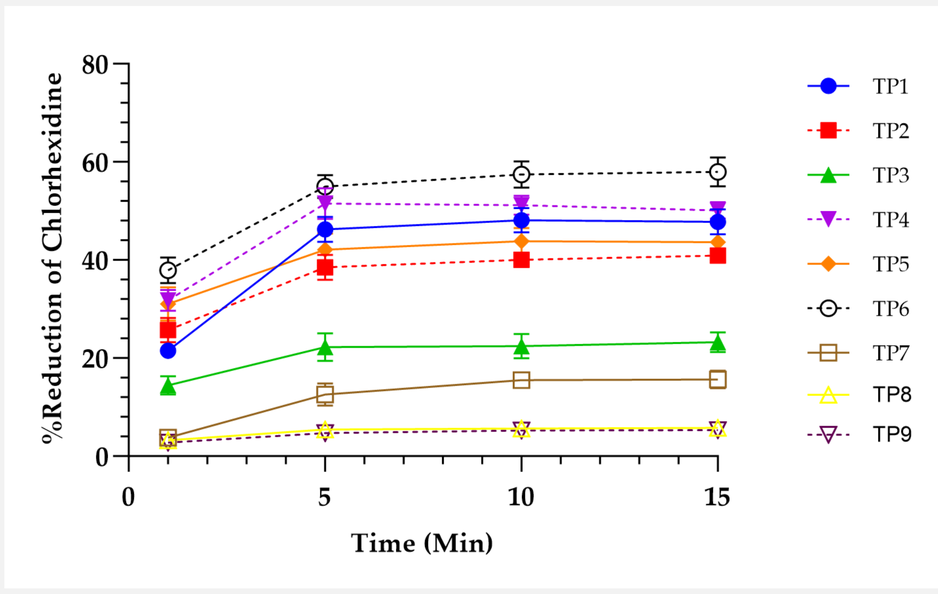


Figure 3. Percent reduction of CHG after 1-, 5-, 10-, and 15-min exposure to toothpastes.

3. Therapeutic Incompatibility

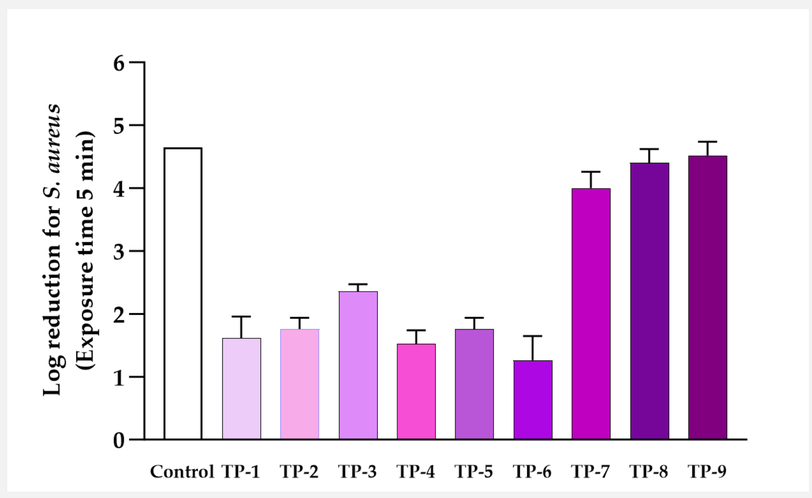


Figure 4. Log reduction of *S. aureus* after 5-min exposure to a mixture of CHG and toothpaste.

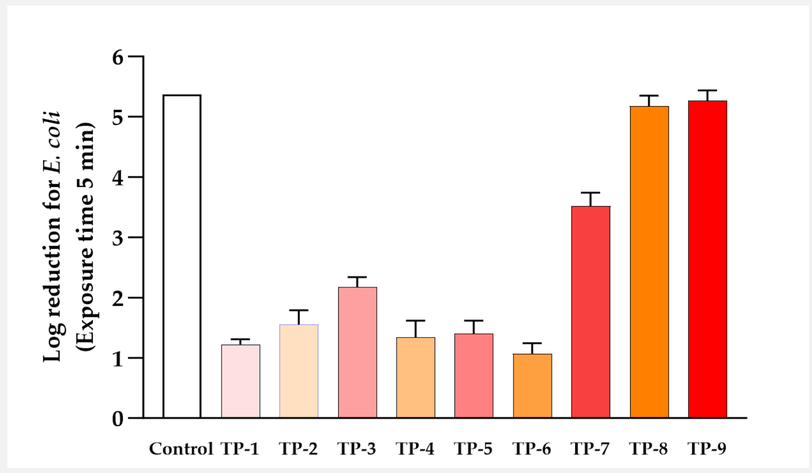


Figure 5. Log reduction of *E. coli* after 5-min exposure to a mixture of CHG and toothpaste.

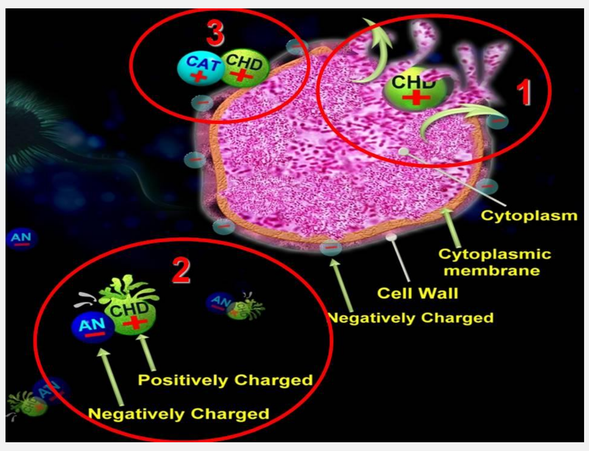


Figure 6. Schematic of Positively Charged CHG (or Cationic Agent) Interactions with Negatively Charged Bacterial Cell Surface, Cat-CHD Co-binding, and Membrane Disruption.

4. Clinical Application

The clinical study demonstrated a significant reduction in VAP rate from 7.74 to 5.30 per 1,000 ventilator-days (31.52% reduction, $p < 0.05$) after implementing the single-use oral care sets.

CONCLUSION

Anionic and non-ionic surfactants in commercial toothpastes may neutralize the positive charge of CHG, reducing its antibacterial activity. The developed CHG-compatible toothpaste in single-use oral care sets, applied under a standardized protocol, effectively reduced VAP incidence in ICU patients.