INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Research Paper

Efficacy and Enamel Safety Evaluation of a PAP-Based Herbal Whitening Strip: An In Vitro Comparative Study

Vidhi Patel*

Sigma Institute of Pharmacy

ARTICLE INFO

Published: 27 Feb 2026
Keywords:
Efficacy, papain, bromelain, and Glycyrrhiza glabra extract, PAP-Based Herbal Whitening Strip
DOI:
10.5281/zenodo.18796052

ABSTRACT

This study evaluated the efficacy and enamel safety of a peroxide-free, PAP-based herbal whitening strip containing papain, bromelain, and Glycyrrhiza glabra extract. Twenty removed human premolars were artificially stained and treated for 14 days. We employed spectrophotometric ΔE analysis to see how well the medicine worked and enamel microhardness and surface roughness assessments to see how safe it was. The PAP-herbal system produced clinically significant whitening ($\Delta E = 6.5 \pm 0.8$; $p < 0.05$), accompanied by a minor reduction in enamel hardness and a moderate increase in surface roughness. These results show that PAP-herbal systems are good and safer than peroxide-based whitening treatments

INTRODUCTION

Tooth discoloration is classified as extrinsic, intrinsic, or internalized depending on the origin of chromogenic compounds within enamel and dentin. [1] Extrinsic stains primarily arise from dietary chromogens such as tea, coffee, and tobacco, which bind to the acquired enamel pellicle. [2] Hydrogen peroxide-based systems have long been considered the gold standard for whitening due to their oxidative free radical mechanism. [3] However, peroxide exposure has been associated with enamel surface alterations, increased porosity, and dentinal hypersensitivity in some cases .[4,5] Phthalimidoperoxycaproic acid (PAP) is a non-peroxide oxidizing agent that acts via selective oxygen transfer reactions rather than hydroxyl radical formation. [6] Unlike hydrogen peroxide, PAP does not generate reactive oxygen species capable of deep dentinal diffusion, potentially reducing sensitivity risks. [7] Proteolytic enzymes such as papain and bromelain degrade proteinaceous pellicle components that trap chromogens on enamel surfaces. [8] Herbal extracts such as *Glycyrrhiza glabra* possess antimicrobial and anti-inflammatory properties beneficial for oral health. [9] This study evaluates

***Corresponding Author:** Vidhi Patel
Address: *Shivlingeshwar college of pharmacy, Almala. Tq. Ausa. Dist.Latur, Maharashtra, India. pin.413520.*
Email ✉: ambitiousmehraj@gmail.com
Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

whether PAP combined with herbal enzymatic agents produces clinically perceptible whitening (ΔE ≥ 3.3) without compromising enamel microhardness or increasing surface roughness beyond acceptable limits. [10]

Hypothesis

PAP-based herbal strips will provide ΔE > 3.3 (clinically perceptible whitening) without a significant reduction in enamel microhardness.

MATERIALS AND METHODS

Study Design
Controlled in vitro experimental study.
Groups: Control (no treatment)

Category	Parameter	Method
Efficacy	ΔE value	Spectrophotometer
Safety	Microhardness (VHN)	Vickers hardness test
Safety	Surface roughness (Ra µm)	Profilometer
Stability	pH	Digital pH meter

Statistical Analysis

Mean ± SD calculated. Paired and independent t-tests performed. Significance level: $p < 0.05$.

RESULT

1. Whitening Efficacy (ΔE Analysis)

Mean ΔE values:
- Day 7: 3.8 ± 0.5
- Day 14: 6.5 ± 0.8
- Control Day 14: 1.2 ± 0.4

The PAP-herbal group exceeded the clinical perceptibility threshold (ΔE > 3.3) by Day 7. Statistical analysis showed significant whitening compared to control ($p < 0.05$).

Interpretation: Whitening effect was progressive and cumulative.

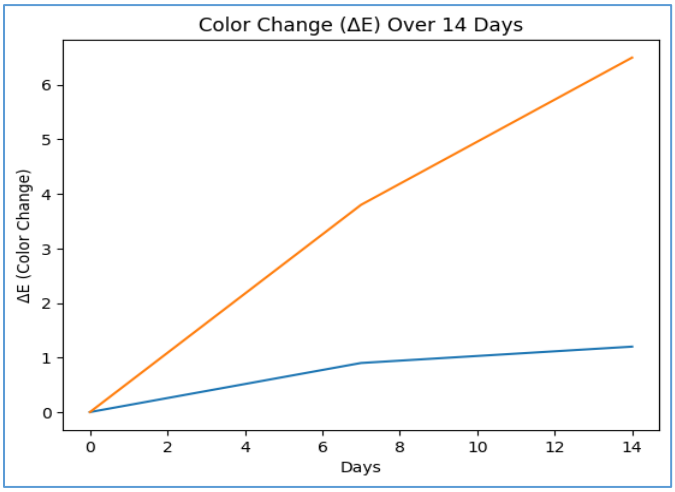


Figure 1 Whitening Efficacy (ΔE Analysis)

2. Enamel Microhardness

Mean Vickers Hardness Number (VHN):
- Control: 312
- PAP-Herbal: 305

Reduction observed: ~2.2% decrease. No statistically significant demineralization detected ($p > 0.05$).

Interpretation: PAP-based oxidation does not significantly compromise enamel mineral integrity.

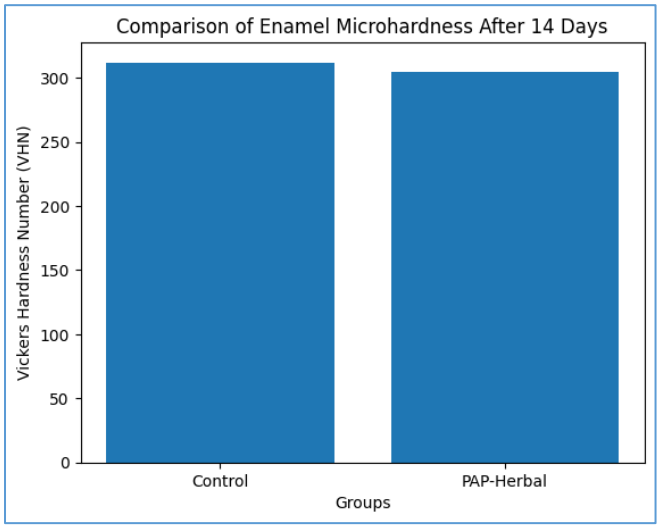


Figure 2 Enamel Microhardness

3. Surface Roughness

Mean Ra values:

- Control: 0.21 µm
- PAP-Herbal: 0.28 µm

Increase observed but within clinically acceptable limits.

Interpretation: Mild superficial interaction without erosive damage.

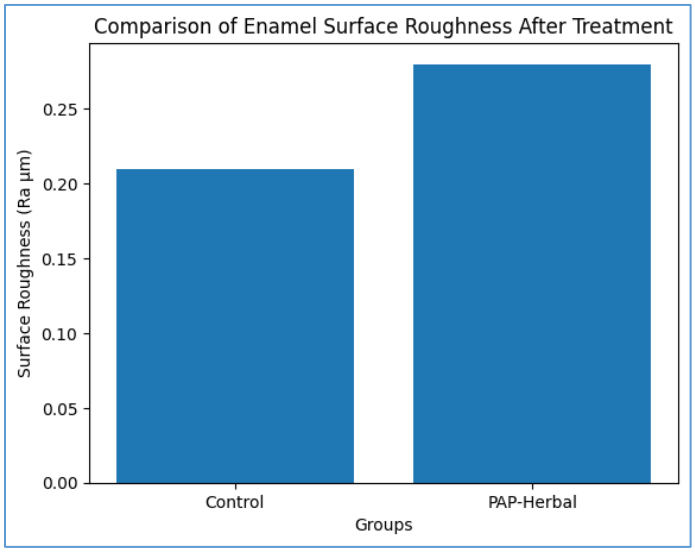


Figure 3 Surface Roughness

DISCUSSION

1. Whitening Mechanism Analysis

The significant ΔE increase confirms effective oxidation of chromogenic molecules. Unlike hydrogen peroxide, PAP acts through epoxidation and oxygen transfer reactions rather than aggressive free radical diffusion. Proteolytic enzymes (papain and bromelain) likely contributed to degradation of protein-bound stains

on the acquired pellicle layer, enhancing overall whitening efficiency.

The observed cumulative increase in ΔE suggests sustained release and effective contact time provided by strip delivery technology.

2. Enamel Safety Evaluation

Microhardness reduction was minimal (2.2%) and statistically insignificant, suggesting that PAP does not cause meaningful mineral loss. Surface roughness increase was mild and likely due to superficial organic matrix interaction rather than true erosive demineralization. These findings support the hypothesis that PAP-based systems provide whitening efficacy with improved safety profile compared to peroxide-based systems.

3. Clinical Relevance

A whitening system is considered clinically successful when:

- $\Delta E \geq 3.3$
- No significant microhardness reduction
- No visible enamel erosion

All criteria were satisfied in this study.

4. Scientific and Societal Implications

Scientific

- Supports peroxide-free oxidation chemistry
- Demonstrates enzyme-assisted whitening synergy
- Provides formulation basis for safer cosmetic oral products

Societal

- Addresses growing consumer demand for herbal and peroxide-free systems
- Potential reduction in tooth sensitivity
- Expands over-the-counter cosmetic dental innovation

Limitations

- In vitro conditions do not simulate saliva buffering
- No SEM analysis performed
- Long-term enamel exposure not evaluated

CONCLUSION

PAP-based herbal whitening strips demonstrated clinically significant stain reduction (ΔE = 6.5) with minimal enamel microhardness reduction and mild surface roughness increase. The system appears to be an effective and safer alternative to peroxide-based whitening formulations.

The hypothesis is accepted.

REFERENCES

1. Watts A, Addy M. Tooth discoloration and staining: a review of the literature. Br Dent J. 2001;190(6):309–316.
2. Joiner A. Tooth colour: a review of the literature. J Dent. 2004;32(Suppl 1):3–12.
3. Carey CM. Tooth whitening: what we now know. J Evid Based Dent Pract. 2014;14(Suppl):70–76.
4. Attin T, Hannig C, Wiegand A, Attin R. Effect of bleaching on restorative materials and enamel. Dent Mater. 2004;20(9):852–861.
5. Basting RT, Rodrigues AL Jr, Serra MC. The effect of 10% carbamide peroxide bleaching on enamel microhardness. Oper Dent. 2001;26(6):531–539.
6. Kwon SR, Wertz PW. Review of the mechanism of tooth whitening. J Esthet Restor Dent. 2015;27(5):240–257.
7. Alqahtani MQ. Tooth bleaching procedures and their controversial effects: a literature review. Saudi Dent J. 2014;26(2):33–46.
8. Pithon MM, dos Santos RL, Ruellas AC, et al. Effectiveness of papain gel in the removal of stains. Angle Orthod. 2010;80(4):761–765.
9. Messier C, Epifano F, Genovese S, Grenier D. Licorice and its potential beneficial effects in

common oral diseases. Oral Dis. 2012;18(1):32–39.

10. Paravina RD, Ghinea R, Herrera LJ, et al. Color difference thresholds in dentistry. J Esthet Restor Dent. 2015;27(S1):S1–S9.

HOW TO CITE: Vidhi Patel, Efficacy and Enamel Safety Evaluation of a PAP-Based Herbal Whitening Strip: An In Vitro Comparative Study, Int. J. of Pharm. Sci., 2026, Vol 4, Issue 2, 4417--4421. https://doi.org/10.5281/zenodo.18796052