


## IMPACT OF VEGAN TOOTHPASTES ON ENAMEL SURFACE INTEGRITY AFTER EROSION AND ABRASION: A NARRATIVE REVIEW

## IMPACTO DOS CREMES DENTAIS VEGANOS NA INTEGRIDADE DA SUPERFÍCIE DO ESMALTE APÓS EROSÃO E ABRASÃO: UMA REVISÃO NARRATIVA

## IMPACTO DE LAS PASTAS DENTALES VEGANAS EN LA INTEGRIDAD DE LA SUPERFICIE DEL ESMALTE DESPUÉS DE LA EROSIÓN Y LA ABRASIÓN: UNA REVISIÓN NARRATIVA

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**Pedro Guimarães Sampaio Trajano dos Santos<sup>1</sup>, Rosana Maria Coelho Travassos<sup>2</sup>,  
Maria Regina Almeida de Menezes<sup>3</sup>, Vânia Cavalcanti Ribeiro da Silva<sup>4</sup>, Eloiza  
Leonardo de Melo<sup>5</sup>, Josué Alves<sup>6</sup>, Verônica Maria de Sá Rodrigues<sup>7</sup>, Luciane Farias  
de Araujo<sup>8</sup>, Tereza Cristina Correia<sup>9</sup>, Gleicy Fátima Medeiros de Souza<sup>10</sup>, Adriane  
Tenório Dourado Chaves<sup>11</sup>, Viviane Ferreira Guimarães Xavier<sup>12</sup>**

### ABSTRACT

**Objective:** To evaluate the impact of vegan toothpastes on enamel surface integrity after erosive and abrasive challenges based on available scientific evidence.

**Methodology:** A narrative review of in vitro, in situ, and clinical studies retrieved from PubMed, Scopus, and Web of Science. Studies comparing vegan and conventional toothpastes regarding abrasivity, remineralization potential, and enamel protection were included.

**Results:** Evidence shows high variability among vegan toothpaste formulations. Fluoride-free products or those containing alternative abrasives may lead to increased enamel loss after erosion and abrasion. Conversely, vegan toothpastes formulated with fluoride, hydroxyapatite, or bioactive compounds demonstrated comparable performance to conventional toothpastes.

<sup>1</sup> Undergraduate in Dentistry. Faculdade de Odontologia do Recife. Pernambuco, Brazil.

E-mail: pedroguimaraessampaio@gmail.com

<sup>2</sup> Dr. in Endodontics. Universidade de Pernambuco (UPE). Pernambuco, Brazil.

E-mail: rosana.travassos@upe.br

<sup>3</sup> Dr. Universidade de Pernambuco (UPE). Pernambuco, Brazil. E-mail: regina.menezes@upe.br

<sup>4</sup> Dr. in Dentistry. Universidade de Pernambuco (UPE). Pernambuco, Brazil. E-mail: vania.silva@upe.br

<sup>5</sup> Dr. in Dentistry. Universidade de Pernambuco (UPE). Pernambuco, Brazil. E-mail: eloiza.leonardo@upe.br

<sup>6</sup> Dr. Universidade de Pernambuco (UPE). Pernambuco, Brazil. E-mail: Josue.alves@upe.br

<sup>7</sup> Dr. in Dentistry. Universidade de Pernambuco (UPE). Pernambuco, Brazil.

E-mail: veronica.rodrigues@upe.br

<sup>8</sup> Dr. in Radiology. Universidade de Pernambuco (UPE). Pernambuco, Brazil. E-mail: luciane.araujo@upe.br

<sup>9</sup> Dr. Universidade de Pernambuco (UPE). Pernambuco, Brazil. E-mail: tereza.correia@upe.com.br

<sup>10</sup> Dr. Universidade de Pernambuco (UPE). Pernambuco, Brazil. E-mail: gleicy.medeiros@upe.br

<sup>11</sup> Dr. Universidade de Pernambuco (UPE). Pernambuco, Brazil. E-mail: adriane.chaves@upe.br

<sup>12</sup> Dr. in Dentistry. Universidade de Pernambuco (UPE). Pernambuco, Brazil. E-mail: vi.xavier@hotmail.com

**Conclusion:** Vegan toothpastes are not a homogeneous category in terms of safety and efficacy. Enamel integrity is primarily influenced by formulation characteristics rather than the exclusion of animal-derived ingredients, underscoring the importance of scientific validation.

**Keywords:** Vegan Toothpastes. Dental Erosion. Dental Abrasion. Enamel Integrity. Oral Hygiene.

## RESUMO

**Objetivo:** Avaliar o impacto dos dentífricos veganos na integridade superficial do esmalte dental após desafios erosivos e abrasivos, com base na literatura científica disponível.

**Metodologia:** Revisão narrativa de estudos in vitro, in situ e clínicos obtidos nas bases PubMed, Scopus e Web of Science. Foram incluídas pesquisas que compararam dentífricos veganos com formulações convencionais quanto à abrasividade, potencial remineralizante e proteção do esmalte.

**Resultados:** Os estudos indicam que os dentífricos veganos apresentam ampla variabilidade em composição e desempenho. Formulações livres de flúor ou com abrasivos alternativos podem resultar em maior perda de esmalte após erosão e abrasão. Por outro lado, produtos veganos contendo flúor, hidroxiapatita ou compostos bioativos demonstraram desempenho semelhante aos dentífricos convencionais.

**Conclusão:** Dentífricos veganos não constituem um grupo homogêneo em termos de segurança e eficácia. A integridade do esmalte depende mais da formulação específica do que da ausência de ingredientes de origem animal, destacando a necessidade de avaliação científica criteriosa desses produtos.

**Palavras-Chaves:** Dentífricos Veganos. Erosão Dentária. Abrasão Dentária. Esmalte Dentário. Higiene Oral.

## RESUMEN

**Objetivo:** Evaluar el impacto de los dentífricos veganos en la integridad superficial del esmalte dental tras desafíos erosivos y abrasivos, con base en la literatura científica disponible.

**Metodología:** Revisión narrativa de estudios in vitro, in situ y clínicos obtenidos de las bases de datos PubMed, Scopus y Web of Science. Se incluyeron investigaciones que compararon dentífricos veganos con formulaciones convencionales en cuanto a abrasividad, potencial remineralizante y protección del esmalte.

**Resultados:** Los estudios indican que los dentífricos veganos presentan una amplia variabilidad en composición y desempeño. Las formulaciones libres de flúor o con abrasivos alternativos pueden dar lugar a una mayor pérdida de esmalte tras la erosión y la abrasión. Por otro lado, los productos veganos que contienen flúor, hidroxiapatita o compuestos bioactivos mostraron un desempeño similar al de los dentífricos convencionales.

**Conclusión:** Los dentífricos veganos no constituyen un grupo homogéneo en términos de seguridad y eficacia. La integridad del esmalte depende más de la formulación específica

que de la ausencia de ingredientes de origen animal, lo que resalta la necesidad de una evaluación científica rigurosa de estos productos.

**Palabras clave:** Dentífricos Veganos. Erosión Dental. Abrasión Dental. Esmalte Dental. Higiene Oral.

## 1 INTRODUCTION

The demand for vegan and cruelty-free personal care products has expanded rapidly, driven by ethical, environmental, and health-related motivations (Whelan & Burke, 2021). In dentistry, this trend has led to a growing market of vegan toothpastes, often characterized by the exclusion of animal-derived ingredients and, in some cases, fluoride or conventional abrasives. However, the implications of these formulation changes for enamel preservation remain insufficiently explored.

Dental erosion and abrasion are multifactorial conditions resulting from chemical dissolution by dietary acids and mechanical wear during toothbrushing, respectively (Lussi & Carvalho, 2014). When combined, these processes can accelerate irreversible enamel loss, compromise surface integrity, and increase susceptibility to hypersensitivity and caries (Shellis et al., 2014). Dentifrice composition plays a critical role in modulating these effects, particularly with respect to abrasivity and remineralizing potential.

Despite increasing consumer interest, vegan toothpastes represent a highly heterogeneous group of products with substantial variability in active ingredients and abrasive systems. The absence of standardized formulations and limited clinical validation raise concerns regarding their safety and efficacy under erosive–abrasive challenges (Joiner, 2019). Therefore, a critical appraisal of the available evidence is essential to guide clinicians and inform evidence-based recommendations.

## 2 METHODOLOGY

This narrative review followed methodological principles recommended for qualitative synthesis of experimental and clinical evidence (Greenhalgh et al., 2018). Searches were conducted in PubMed, Scopus, and Web of Science using terms related to vegan toothpaste, enamel erosion, and abrasion.

Studies were eligible if they evaluated enamel surface changes, hardness, roughness, or wear following exposure to vegan dentifrices. Both laboratory-based and clinical studies were included to capture a comprehensive perspective.

The findings were synthesized descriptively, focusing on formulation characteristics, abrasive systems, and active ingredients. Emphasis was placed on identifying trends, inconsistencies, and research gaps in the current literature.

### 3 RESULTS

The synthesis of the included evidence demonstrates that the impact of vegan toothpastes on enamel surface integrity after erosive and abrasive challenges is highly formulation-dependent. The reviewed studies encompassed predominantly in vitro models, complemented by limited in situ and clinical investigations, allowing evaluation of enamel wear, surface microhardness, roughness, and morphological alterations.

#### 3.1 ENAMEL WEAR FOLLOWING EROSIVE-ABRASIVE CHALLENGES

Across multiple laboratory protocols simulating acid exposure followed by toothbrushing, fluoride-free vegan toothpastes consistently resulted in greater enamel surface loss when compared with conventional fluoride-containing dentifrices. Profilometric analyses revealed that enamel loss was significantly higher when brushing was performed on previously eroded enamel, corroborating the established concept that erosion-induced softening increases susceptibility to mechanical abrasion (Lussi & Carvalho, 2014; Shellis et al., 2014).

Formulations containing alternative abrasives such as activated charcoal, sodium bicarbonate, calcium carbonate, or coarse silica particles were associated with pronounced surface loss, particularly under standardized brushing cycles representing medium- to long-term use. Relative dentin abrasivity (RDA), although originally designed for dentin, emerged as a useful surrogate indicator of enamel abrasion potential, with higher RDA values correlating with increased enamel wear in erosive-abrasive models (Joiner, 2019).

In contrast, vegan toothpastes incorporating fluoride demonstrated enamel wear values statistically comparable to conventional dentifrices. Studies evaluating stannous fluoride or sodium fluoride formulations showed reduced mineral loss and improved surface resistance, even after repeated erosive challenges, highlighting the critical role of fluoride in forming acid-resistant mineral phases on enamel surfaces (Schlueter et al., 2020).

#### 3.2 SURFACE MICROHARDNESS RECOVERY

Surface microhardness measurements consistently indicated incomplete recovery of enamel hardness following erosive episodes when fluoride-free vegan toothpastes were used. In several studies, post-brushing microhardness values remained significantly lower than baseline, suggesting insufficient remineralization and increased vulnerability to cumulative wear (Ganss & Lussi, 2014).

Conversely, vegan formulations containing hydroxyapatite, nano-hydroxyapatite, or calcium–phosphate-based bioactive systems demonstrated a significant increase in post-treatment microhardness. These agents promoted mineral deposition within the softened enamel surface, partially restoring hardness and reducing susceptibility to subsequent abrasion. Although complete recovery to baseline hardness was rarely achieved, outcomes were comparable to those observed with fluoride-containing control dentifrices (Joiner, 2019).

### 3.3 SURFACE ROUGHNESS AND MORPHOLOGICAL ALTERATIONS

Surface roughness analyses revealed that fluoride-free and highly abrasive vegan toothpastes significantly increased enamel roughness after erosion–abrasion cycles. Increased roughness values were consistently associated with irregular surface morphology, as observed through scanning electron microscopy (SEM), characterized by prism exposure, surface pitting, and loss of interprismatic substance (Shellis et al., 2014).

In contrast, vegan toothpastes formulated with low-abrasivity silica systems and remineralizing agents showed smoother post-treatment surfaces, with SEM images demonstrating partial occlusion of surface defects and more homogeneous mineral deposition. These findings suggest that controlled abrasivity combined with bioactive ingredients may mitigate the detrimental effects of erosion–abrasion on enamel microtopography (Schlueter et al., 2020).

### 3.4 INFLUENCE OF TOOTHPASTE COMPOSITION

The results consistently indicated that enamel outcomes were more strongly influenced by toothpaste composition than by the vegan designation itself. The exclusion of animal-derived ingredients did not inherently compromise enamel safety; rather, the absence of fluoride and the use of aggressive abrasive systems were the primary determinants of unfavorable outcomes. This finding underscores the heterogeneity of vegan toothpastes and challenges the assumption that “natural” or “ethical” formulations are intrinsically safer for enamel preservation (Whelan & Burke, 2021).

### 3.5 CLINICAL EVIDENCE

Clinical evidence remains scarce but suggests that vegan toothpastes containing fluoride or effective bioactive remineralizing agents do not exacerbate erosive tooth wear in

low- to moderate-risk individuals. However, fluoride-free vegan formulations showed no protective benefit in patients with high erosive risk, particularly those with acidic diets or reduced salivary flow (Schlueter et al., 2020).

Collectively, the results demonstrate that vegan toothpastes cannot be evaluated as a homogeneous category. Enamel surface integrity after erosion and abrasion is governed by remineralization potential, abrasive characteristics, and fluoride availability, rather than ethical labeling alone.

#### **4 DISCUSSION**

The present narrative review highlights that vegan toothpastes cannot be regarded as a uniform category with respect to their effects on enamel surface integrity under erosive and abrasive challenges. The findings demonstrate that the performance of these products is primarily dictated by their specific formulation characteristics, rather than by the absence of animal-derived ingredients per se. This distinction is critical, as consumer-driven perceptions of “natural” or “vegan” products may not align with their actual protective capacity against enamel wear.

A key aspect emerging from the analyzed evidence is the role of fluoride and alternative remineralizing agents in mitigating enamel loss. Vegan formulations lacking fluoride or containing highly abrasive alternative particles tend to show increased enamel wear, particularly when erosion and abrasion act synergistically. This outcome is consistent with the understanding that erosion softens the enamel surface, rendering it more susceptible to mechanical removal during toothbrushing. In such conditions, abrasivity becomes a decisive factor influencing surface integrity.

Conversely, vegan toothpastes incorporating fluoride, hydroxyapatite, or bioactive compounds demonstrated protective effects comparable to those of conventional dentifrices. These findings reinforce the concept that effective enamel protection relies on remineralization potential and controlled abrasivity, regardless of the ethical positioning of the product. Importantly, some vegan formulations appear to prioritize market appeal over scientific validation, which may explain the heterogeneity observed across studies.

Another relevant consideration is the predominance of laboratory-based evidence in the available literature. While in vitro and in situ models provide valuable insights into erosive–abrasive mechanisms, they cannot fully replicate the complexity of the oral environment, including salivary dynamics, behavioral variability, and long-term use patterns.



This limitation underscores the need for well-designed clinical trials to substantiate laboratory findings and inform evidence-based recommendations.

Overall, the reviewed evidence suggests that clinicians should avoid generalized recommendations regarding vegan toothpastes and instead critically assess individual product formulations. Patient counseling should emphasize that ethical labeling does not inherently guarantee enamel safety, particularly for individuals at high risk of erosive tooth wear.

## 5 CONCLUSION

Vegan toothpastes represent a heterogeneous group of oral hygiene products with markedly different effects on enamel surface integrity following erosion and abrasion. The available evidence indicates that enamel preservation is determined by formulation-specific factors, such as the presence of remineralizing agents and the nature of abrasive systems, rather than by the exclusion of animal-derived ingredients alone.

From a clinical perspective, vegan toothpastes formulated with fluoride or effective bioactive alternatives may be considered safe and comparable to conventional products, whereas fluoride-free or highly abrasive formulations may increase the risk of enamel wear in susceptible individuals. Consequently, product selection should be guided by scientific evidence rather than ethical labeling alone. Further clinical research is warranted to validate long-term outcomes and support informed decision-making in preventive dentistry.

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