

The Effectiveness of Selective Toothpaste Ingredients and Formulations in the Treatment of Gum Health- A Review

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Abstract

Commonly, the packaging of over-the-counter dental products is stated to be 'fighting bacteria, preventing gingivitis and reducing gingival inflammation' to promote the healing of gums. The aim of this review was to assess the claims (made on the packaging, literature, or website) made by both manufacturers and retailers on the selected active ingredients within the various toothpaste formulations. In general, the ingredients in over-the-counter toothpaste support these claims. Nonetheless, further clinical studies are necessary to ascertain the precise effects of these ingredients and current formulations on gum health.

Introduction

According to a recent World Health Organization (WHO) 2022 report (Jain et al. 2024), oral diseases are a major public health problem, and these conditions affect almost 3.5 billion people, with three out of four people

affected living in middle-income countries. These conditions include periodontal disease which is a chronic inflammatory disease of the gingiva and periodontium (gum disease) and dental caries (tooth decay). It is caused by the accumulation of plaque and bacteria. Plaque is a soft layer of biofilm that forms on the tooth surface. Dietary sugars such as sucrose contribute to the formation of plaque (Vranić et al.,2004). An individual's likelihood of

developing periodontal diseases (susceptibility), however, is influenced by their immune and inflammatory responses to the bacteria in dental plaque. Other factors including the importance of maintaining effective oral hygiene is essential for the removal of the plaque biofilm, thereby reducing the potential risk of developing gingivitis and in susceptible individuals' periodontitis (Rajendiran, et al. 2021). The use of supplemental or adjunctive treatments such as toothpaste, mouth rinses etc., is therefore an essential component in the maintenance of effective mouth care. This observation can be reflected in a recent marketing report indicating that the global toothpaste market size was \$18.11 billion in 2022 and was projected to grow from \$18.70 billion in 2023 to \$25.71 billion by 2030. The increasing consumer awareness on the importance of oral care in maintaining a healthy mouth by using high quality oral health products is therefore essential for the projected growth within the market (<https://www.fortunebusinessinsights.com/>).

The aim of this review was to assess the claims (made on the packaging, literature, or website) made by both Manufacturers' and retailers on the selected active ingredients within the various toothpaste formulations. The validity of these claims was assessed through evidence from the available published professional literature (e.g., PubMed) as well as from the selected manufacturers and retailers' websites.

Toothpaste Formulations

Toothpaste comes in various forms, such as pastes, gels and powders that are used in conjunction with toothbrushes to maintain and improve oral health (Lippert, 2013). These products remove plaque and debris from the tooth surface and depending on the active ingredient may protect against dental caries, plaque, and malodour (freshen breath).

Toothpaste Ingredients

The main components of a functional toothpaste are abrasives, humectants, surfactants, binders, and flavouring

agents (Vranić et al., 2004).

- **Abrasive agent** – These enhance the mechanical removal of dental plaque and external stains; however, they are not considered active agents as they do not reduce the risks of cavities (Colgate,2024). Abrasive agents can remove materials stuck to the enamel without damaging it. On the Moh's scale, the hardness of enamel on the tooth surface is 6-7; therefore, the hardness of an abrasive should be less than 3. Ideally, Abrasives should be in the form of small, smooth crystal particles to avoid tooth wear (Vranić et al., 2004). Examples of abrasives are calcium carbonate, sodium bicarbonate, and calcium pyrophosphate (Subramanian et al. ,2017)

- **Humectant** – Retain moisture by preventing water loss and work by binding and holding the solvent inside the dentifrice and provide a toothpaste with a creamy texture. Examples of humectants include glycerin and sorbitol (Vranić et al. 2004)

- **Surfactant** – Surfactants have good foaming, dispersion, suspension, and cleaning qualities. These enable the toothpaste to be distributed within the oral cavity to strengthen the cleaning action and to penetrate the biofilm and remove both plaque and debris. Additionally, they disperse the flavour in the mouth. The most common surfactant is Sodium lauryl sulfate (sodium alkylsulfate succinate, and sodium cocomonoglyceride sulfonate (Vranić et al. 2004, Sälzer et al., 2015)

- **Binder** – Preserves both the stability and consistency to avoid separation of the liquid and powder (Jagtap, 2018). Additionally, these ingredients influence the toothpaste's foaming, dispersion and rinsing in the oral cavity. A common binder used is sodium carboxyl-ethylcellulose (CMC). Examples of polysaccharides that can be used are xanthan gum, sodium alginate and inorganic clay minerals such as bentonite (Vranić et al. 2004, Nikhat & Basar, 2024).

- **Flavouring agent** - Used to add flavour to the toothpaste, leaving it with a clean aftertaste and aroma. They can also be added to the product to sweeten it. Sweetening agents include soluble saccharin, glycerol, and xylitol. Essential oils such as spearmint, menthol and peppermint can also be added to enhance the flavour. Certain oils, such as thymol and eucalyptol can have antibacterial effects (Vranić et al.,2004)

Active agents

Toothpastes contain active agents, which enable them to complete their function. The active agents have many properties such as anti-plaque and anti-caries (Table 1).

Chlorhexidine (CHX) is a bisbiguanide with bacteriostatic and bactericidal effects (Rajendiran et al., 2021). It has broad-spectrum antimicrobial activity and plaque inhibition properties (Vranić et al. 2004). It is effective against gram-positive and gram-negative bacteria and has significant anti-plaque and anti-inflammatory effects on the gingiva and teeth (Vranić et al. 2004). Chlorhexidine is commonly present in mouthwashes (0.2%) (Dues, 2022), gels (0.12-1%) and toothpaste (Rajendiran et al., 2021). However, long-term use results in local side effects such as dysgeusia, teeth staining, and restorative materials (Vranić et al. 2004). More recently Sodium bicarbonate (67%) has also been added to the Corsodyl range of toothpastes to help with the mechanical control of dental biofilm and helps remove plaque and improve gingival health since it is bactericidal against most periodontal pathogens. (Taschieri et al. 2004). It should be noted that most of the published evidence for the effectiveness of Chlorhexidine as an anti-plaque agent in the treatment of periodontal disease (gum health) was based on mouthwashes.

Metal ions

Stannous ions, such as stannous fluoride, stannous chloride, and stannous pyrophosphate, are found in toothpaste. They inhibit the growth of bacteria by preventing plaque to convert urea to ammonia. Additionally, they stop bacterial enzymes. Enamel treated with stannous fluoride becomes hydrophobic, increasing its antiplaque effect (Vranić et al. 2004). According to Ellingsen et al. (1980), Stannous ions also reduce the acidogenicity of dental plaque.

Zinc ions (with Chloride and Citrate) are present in dentifrices and is relatively non-toxic and has plaque-inhibitory properties, which are enhanced by surfactants. It

inhibits the metabolism of *S. mutans* and *S. Sanguis*. Zinc also inhibits the trypsin-like protease activity of *P. gingivalis* and *C. gingivalis* (Vranić et al.,2004) and decreases the rate of demineralisation, thus decreasing the chance of caries (Simmer et al. 2020). Additionally, zinc inhibits the production of Volatile sulphur-containing compounds (VSC), which have a terrible smell (odour), and by inhibiting the production of VSCs, zinc ions may prevent bad breath.

Anti-plaque agents

Sodium lauryl sulphate (SLS) has an antimicrobial effect due to its absorption and penetration through the bacterial cell wall. It interacts with the components of the cell membrane's lipids and proteins (Sabri et al. 2023). SLS has a strong affinity for proteins as it penetrates and denatures them. This allows it to inhibit enzymes which control the regrowth of plaque (Vranić et al., 2004). Side effects of SLS include irritation of the skin and mucosa, mucosal desquamation, and ulcers.

Anti-carious agents

Fluoride is a recognized anti-carious agent and is present in toothpastes (also mouth rinses, gels etc.,) in different forms, such as sodium mono-fluoro-phosphate (SMPF) and amine fluoride. The most common form is sodium fluoride (NaF), although. Fluoride inhibits the demineralization of enamel. Hydroxyapatite crystals in teeth react with fluoride ions, forming fluorapatite, which is more resistant to acid dissolution (Fig. 1).

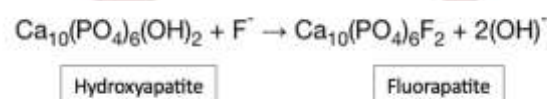


Figure 1: Reaction when fluoride ions are added to hydroxyapatite crystals in enamel, this happens as a dynamic equilibrium.

Fluoride inhibits plaque bacteria by travelling through the cariogenic bacterial cell wall as Hydrogen fluoride (HF) and subsequently dissociates inside the cell into H⁺ and F⁻ ions, acidifying the bacteria and inhibiting the bacterial enzymes (Nassar and Brizuela, 2022). However, excess fluoride can cause dental fluorosis, where small white specks can be observed on the enamel. There are detrimental effects of excess fluoride, such as osteoporosis

and muscular damage. However, the amount of fluoride present in dentifrices is much lower than the dosage that would cause such problems (Wang. et al.,2019, Solanki, et al, 2022). Commonly, fluoride found in toothpastes is between 1000-1500ppm. Children under seven are recommended to use 1000ppm, and children over seven are to use 1350-1500ppm (Fluoride, 2022).

Selected active agents and supporting evidence (Table 1).

Active agent	Evidence
Chlorhexidine	<p><i>Randomized control study on the acceptability of chlorohexidine.</i></p> <ul style="list-style-type: none"> • Assesses the effectiveness of a product containing chlorhexidine on individuals with periodontal disease. • 60 subjects displaying mild-moderate symptoms of gingivitis were randomly allocated to receive either toothpaste containing chlorhexidine or a mouthwash containing chlorhexidine. • Periodontal disease index (PDI) was used to evaluate clinical signs. • Substantial enhancements in PDI scores post-treatment were observed in both groups, with all participants reporting healthier and/or reduced bleeding gums. This suggests that chlorhexidine effectively alleviates symptoms of gingivitis (Magaz et al, 2018).
Stannous fluoride	<p><i>Randomized control study</i></p> <ul style="list-style-type: none"> • Investigating efficacy of stannous fluoride toothpaste in improving gingival health • Conducted in an examiner-blind manner to assess the anti-gingivitis efficacy of a non-aqueous (anhydrous) 0.454% w/w stannous fluoride toothpaste ("Test") compared to a sodium mono-fluorophosphate toothpaste ("Control") among individuals with mild to moderate gingivitis. • Participants brushed daily with either the test or control toothpaste for a duration of three weeks. • The variables examined were the difference in bleeding index (BI), the difference in the number of bleeding sites (MGI), and plaque index (TPI). • The study reported statistically significant reductions in gingival bleeding, gingival inflammation, and plaque levels among adults with mild to moderate gingivitis when using the stannous fluoride toothpaste (Acherkouk et al. 2021).
Sodium fluoride	<i>Systematic review and meta-analysis</i>

	<ul style="list-style-type: none"> • A search for randomized clinical trials was conducted in six electronic databases. • The search identified 1932 records and 159 full-text articles that were read by two examiners. • Information relating to the characteristics of participants, interventions, outcomes, length of follow-up and potential of bias were independently assessed by two examiners based of predetermined criteria. • Results showed that there was a significant reduction of caries with patients using fluoride toothpaste vs patients who were using a placebo / no intervention (dos Santos et al. 2013)
<p>Sodium bicarbonate</p>	<p style="text-align: center;"><i>Systematic review and meta-analysis –</i></p> <p style="text-align: center;">Efficacy of 67% sodium bicarbonate toothpaste for plaque and gingivitis control (Taschieri et al. 2022)</p> <ul style="list-style-type: none"> • evaluates the efficacy of a 67% sodium bicarbonate-based toothpaste for gingival health parameters improvement in individuals with gingivitis. • Electronic searches such as MEDLINE, Scopus, Cochrane were searched for randomized control trials. • Data on gingival, bleeding, and plaque indices were extracted from the chosen studies, which then underwent risk-of-bias assessment. A meta-analysis was conducted to determine the combined effect. • Results show significant improvement of gingival index, bleeding index, and plaque index in patients using sodium bicarbonate toothpaste as compared with control subjects. • In vitro studies would suggest that Sodium bicarbonate was able to disrupt mature dental plaque grown in vitro and that its reported efficacy in maintaining oral hygiene may be related to this key factor (Pratten et al. 2016). • Six-month studies indicate that a 62% or 67% sodium bicarbonate toothpaste improved plaque, bleeding, and gingival indices (Jose et al. 2018, Mason et al. 2021)
<p>Zinc ions</p>	<p style="text-align: center;"><i>A 6-month control study in adults</i></p> <ul style="list-style-type: none"> - Evaluates the efficacy of a dentifrice containing 2% zinc citrate and 0.76% sodium monofluorophosphate in a silica base (zinc citrate dentifrice) for the control of supragingival plaque and gingivitis, compared to a control (no zinc) - A stratified sample comprising both men and women was instructed to brush their teeth for one minute each morning and night. Examinations were conducted at the beginning, at three months, and at six months. - Analysis of both the three and six-month assessments revealed statistically

significant reductions in both plaque and gingivitis within the zinc citrate dentifrice group compared to the control group, as per whole-mouth data (Williams et al., 1998).

Table 1: Selected Active agents and supporting evidence (Acknowledgement: Selected papers as mentioned above)

Over the counter toothpastes claims and observations (Table 2)

The packaging/labelling of most toothpastes have numerous claims regarding the advantages of the active agents, such as preventing bleeding, promoting gum health, and fighting plaque. Packaging often states that the product with its active ingredients was 'scientifically proven/clinically tested'. A search of online supermarket websites identified toothpastes that claimed to help with 'gingivitis', together with the acquired information assessing the claims on each product with the individual active agents identified in each toothpaste (Table 2).

Product	Claims	Literature support	Ingredients (active agents highlighted)
Corsodyl Complete Protection Gum Care Whitening Toothpaste Extra Fresh 75ml (Corsodyl,2023)	'Helps stop and prevent bleeding and reduces red and inflamed gums' (Corsodyl, 2023)	Contains sodium fluoride which has anti-bacterial and anti-carious affects (Rajendiran et al.) Contains sodium bicarbonate, evidence suggests that is its anti-plaque and reduces inflammation (Taschieri et al.)	Sodium Bicarbonate, Aqua, Glycerin, Hydrated Silica, Sodium Lauryl Sulfate, Aroma, Xanthan Gum, Cocamidopropyl Betaine, Sodium Saccharin, Sodium Fluoride, Titanium Dioxide, Steviol Glycosides, Limonene, CI 77491, Contains Sodium Fluoride 0.31% w/w (1400 ppm fluoride)
Oral-B Gum & Enamel Original Toothpaste 75ml (Oral B, 2023)	'Rejuvenate gums with its antibacterial action' (Oral B, 2023)	Contains stannous fluoride which has anti-plaque properties (Fiorillo et al.,2020)	Glycerin, Hydrated Silica, Sodium Hexametaphosphate, PEG-6, Propylene Glycol, Aqua, Zinc Lactate, Sodium Gluconate, CI 77891, Sodium Lauryl Sulfate, Silica, Aroma, Sodium Saccharin, Chondrus Crispus Powder, Trisodium Phosphate, Stannous Fluoride, Stannous Chloride, Xanthan Gum, Sodium Fluoride

<p>Sensodyne Sensitivity Gum & Enamel Toothpaste 75ml (Sensodyne, 2023)</p>	<p>‘Promote gum health, removes plaque bacteria in the hard-to-reach places, strong & healthy gums’ (Sensodyne,2023)</p>	<p>Contains stannous fluoride which has anti-plaque properties.</p> <p>Contains SLS which helps remove plaque (Barkvoll, 1989)</p> <p>Contains sodium fluoride which has anti-bacterial and anti-carious affects</p>	<p>Glycerin, PEG-8, Hydrated Silica, Pentasodium Triphosphate, Aroma, Sodium Lauryl Sulfate, Titanium Dioxide, Carbomer, Stannous Fluoride, Cocamidopropyl Betaine, Sodium Saccharin, Silica, Sodium Fluoride, Limonene. Contains Stannous Fluoride 0.454% w/w & Sodium Fluoride</p>
<p>Corsodyl Gum, Breath & Sensitivity Whitening Toothpaste 75ml (Corsodyl,2023)</p>	<p>‘Targets gum problems and plaque bacteria deep between the teeth’ (Corsodyl,2023)</p>	<p>Contains SLS which helps remove plaque.</p>	<p>Glycerin, PEG-8, Hydrated Silica, Pentasodium Triphosphate, Aroma, Sodium Lauryl Sulfate, Titanium Dioxide, Carbomer, Stannous Fluoride, Cocamidopropyl Betaine, Sodium Saccharin, Zinc Chloride, Carrageenan, Sodium Fluoride, Limonene. Contains Stannous Fluoride 0.4540% w/w and Sodium Fluoride 0.0721% w/w.</p>
<p>Colgate Total Advanced Gum Care + Sensitive Toothpaste (Colgate,2023)</p>	<p>‘Fight plaque bacteria’ (Colgate,2023)</p>	<p>Contains sodium fluoride which has anti-bacterial and anti-carious affects</p>	<p>Sodium Fluoride Total Fluoride content: 1450 ppm</p>
<p>Active Gum Repair Fresh Mint Toothpaste (Parodontax,2023)</p>	<p>‘Anticavity, anti-gingivitis’ (Parodontax, 2023)</p>	<p>Contains stannous fluoride which has anti-plaque properties.</p>	<p>Stannous fluoride 0.0454% (0.15% w/v fluoride ion) (Parodontax, 2023)</p>
<p>Curasept toothpaste 0.05% 75ml (dental direct,2023)</p>	<p>‘Protects gums and teeth against attack of harmful bacteria’ (Dental Direct)</p>	<p>Contains chlorohexidine which has significant anti-inflammatory and antiplaque effects on gingiva and teeth (Poppolo Deus and Ouanounou, 2022). Contains sodium fluoride which has anti-bacterial and anti-carious affects</p>	<p>Sorbitol, water, hydrated silica, glycerin, xylitol, peg-40, hydrogenated castor oil, cocamidopropyl betaine, aroma, ascorbic acid, sodium metabisulite, cellulose gum, sodium fluoride, chlorhexidine, sodium saccharin, sodium methylparaben, sodium citrate (mouthulcers, 2023)</p>

<p>Corsodyl Ultra Clean Daily Gum Care Fluoride Toothpaste 75ml (Boots,2023)</p>	<p>‘Reduces bleeding gums, removes plaque and helps keep the seal between your gums and teeth tight’ (Boots, 2023)</p>	<p>Contains sodium bicarbonate, evidence suggests that is its anti-plaque and reduces inflammation.</p> <p>Contains sodium fluoride which has anti-bacterial and anti-cariious affects</p>	<p>Sodium Bicarbonate, Aqua, Glycerine, Hydrated Silica, Cocamidopropyl Betaine, Aroma, Xanthan Gum, Sodium Fluoride, Sodium Saccharin, Titanium Dioxide, Limonene, CI 77491</p> <p>Contains: Sodium Fluoride 0.315% w/w (1450 ppm Fluoride)</p>
<p>Corsodyl 1% w/w Dental Gel. (Corsodyl 2023)</p>	<p>‘Treat and prevent gum problems, such as red, swollen or bleeding gums’ (Corsodyl 2023).</p>	<p>Contains chlorohexidine which has significant anti-inflammatory and anti-plaque effects on gingiva and teeth.</p>	<p>Chlorhexidine Digluconate 1% w/w. Other ingredients: Hydroxypropylcellulose, macrogolglycerol hydroxystearate, sodium acetate, levomenthol, peppermint oil, isopropyl alcohol, and water (Corsodyl, 2023).</p>
<p>Gengigel Gel 20ml (Gengigel, 2023)</p>	<p>‘Reduces inflammation and soothes pain. it speeds up tissue repair and wound healing. it offers a protective barrier to help prevent infection’ (Gengigel, 2023)</p>	<p>Contains sodium hyaluronate.</p> <p>Hyaluronan gel, reduces inflammation and gingival bleeding and has tissue healing properties (Mesa et al., 2002, Dahiya & Kamal 2013)</p>	<p>Aqua, Xylitol, Cellulose Gum, Alcohol, PEG 40 Hydrogenated Castor Oil, PVA, Polycarbophil, Dichlorobenzyl Alcohol, Aroma (CITROMINT 1/074600), Sodium Hydroxide, Acid Blue 9 (CI 42090). Principal ingredient: Sodium Hyaluronate.</p>

Table 2: Table of claims and evidence for toothpastes and gels (Acknowledgement: Manufacturers’ and retailers’ websites, selected papers)

Discussion

The purpose of this literature review was to evaluate the claims made on the packaging/labelling of selected toothbrush brands. The packaging of over-the-counter toothpaste feature various claims, such as ‘fight cavities, reducing inflammation, protecting gums, fights plaque etc.,’ which are supported by the existing published literature, although it should be noted that some of the claims may be based on earlier toothpaste formulation

(products). According to a UK Which Consumer Report, although these claims by manufacturers are generally supported in the published literature, the overall benefits of these expensive formulations may be marginal compared to cheaper formulations (Which Report 2022). Most Manufacturers, however, tend to make claims under the Cosmetic regulations rather than making a clinical claim such as ‘prevents gingivitis’ etc., which would also require clinical evidence from well-conducted randomised clinical trials (RCT) to claim clinical efficacy (CTPA 2023). One

of the advantages of publishing these claims on the packaging is that this enables the consumer to identify a product that addresses their oral care requirements. For example, if a patient is looking for a specific recommended toothpaste for 'bleeding gums', they can purchase any of the toothpastes (contain the active ingredients) in this review. The question remains (at least from the consumer's perspective) is what values drive the choices made by the consumer. It is evident that manufacturers spend considerable sums of money on research, marketing etc., building up a story that may convince the consumer of the effectiveness of the specific ingredients of their products. This strategy is bolstered by publications in peer review journals and often reinforced by professional recommendation. However, there are other consumer preferences to consider, such as the availability and quality of a particular toothpaste or recommended branded product(s) (e.g., Dentist recommendation or from manufacturing advertising and promotions or Brand loyalty).

Other factors may also influence the choice of a toothpaste when purchasing oral care products, such as looking for product specifically targeted at prevention of dental caries, gum health, tooth whitening, bad breath (breath freshening) or more recently herbal and vegan products etc. The cost or discounted items may also influence the choice of an oral care product as well as the choice of purchasing these products on-line rather than in a store or pharmacy (Acharya et al. 2018). However, it should be recognised that simply using a particular toothpaste without good oral hygiene practice(s), such as correct atraumatic toothbrushing techniques or interdental cleaning etc., together with routine dental appointments to maintain overall oral health, may be insufficient for the prevention of disease progression.

Conclusion

Overall, based on this review, the claims made by the manufacturers and retailers on packaging/labelling and literature from their websites are substantiated by the published literature, however more evidence from clinical studies is required to determine the efficacy of currently

formulated toothpastes on gum health.

References

1. Acharya, S. Ubeja, S. Jain, P, Loya A, "Consumer Buying Behaviour towards Toothpaste", International Journal of Computer Sciences and Engineering, Vol.06, Special Issue.09, pp.74-82, 2018.
2. Acherkouk, A., Patel, N., Butler, A. et al. A randomised clinical study investigating efficacy of a stannous fluoride toothpaste in improving gingival health after 3 weeks' use. BMC Oral Health 21, 441 (2021). <https://doi.org/10.1186/s12903-021-01727-5>
3. Barkvoll P. [Should toothpastes foam? Sodium lauryl sulfate--a toothpaste detergent in focus]. Den Norske Tannlaegeforenings Tidende. 1989 Feb;99(3):82-84. PMID: 2696932.
4. Basar HN, Sharma AS, Sharan M, Vyas D, Sushmitha D, Kour T (2022) Dentifrices: Its composition, forms, and function – a literature review. J Ind Dent Assoc Kochi 2022;4 (1):25-32.
5. Boots (2023) Corsodyl Gum Care Ultra Clean Toothpaste 75ml - Boots. <https://www.boots.com>
6. Bruun C, Givskov H, Thylstrup A. Whole saliva fluoride after toothbrushing with NaF and MFP dentifrices with different F concentrations. Caries Res. 1984;18(3):282-8. [PubMed:

- 6584220]
7. Colgate (2023) Colgate® Total Advanced Gum Care Toothpaste. <https://www.colgate.com/>. Accessed April 2024.
 8. Corsodyl (2023) Treat Bleeding Gums With Corsodyl www.Corsodyl.co.uk. Accessed April 2024.
 9. CTPA Guide on Classification of Toothpaste Claims Borderline issues between Cosmetics and Medicinal Products or medical devices Common Understanding (2023) NEW CTPA Guide on Common Understanding of Borderline Toothpaste Claims.
 10. Dahiya P, Kamal R. Hyaluronic Acid: a boon in periodontal therapy. *N Am J Med Sci.* 2013 May;5(5):309-15. doi: 10.4103/1947-2714.112473. PMID: 23814761; PMCID: PMC3690787.
 11. Dental Direct (2023) Curasept Chlorhexidine Gum Toothpaste 0.05% 75ml (<https://www.dentaldirect.co.uk/>)
 12. Dos Santos AP, Nadanovsky P, de Oliveira BH. A systematic review and meta-analysis of the effects of fluoride toothpastes on the prevention of dental caries in the primary dentition of preschool children. *Community Dent Oral Epidemiol.* 2013 Feb;41(1):1-12. [PubMed]
 13. Dues, O, "Chlorhexidine in Dentistry: Pharmacology, Uses, and Adverse Effects." *International Dental Journal*, vol. 72, no. 3, Mar. 2022, <https://doi.org/10.1016/j.identj.2022.01.005>.
 14. Ellingsen, J. E., Svaton, B., & Rölla, G. (1980). The effects of stannous and stannic ions on the formation and acidogenicity of dental plaque in vivo. *Acta Odontologica Scandinavica*, 38(4), 219–222. <https://doi.org/10.3109/00016358009003492>
 15. Fiorillo L, Cervino G, Herford AS, Laino L, Cicciù M. Stannous Fluoride Effects on Enamel: A Systematic Review. *Biomimetics (Basel)*. 2020 Aug 31;5(3):41. doi: 10.3390/biomimetics5030041. PMID: 32878006; PMCID: PMC7559150.
 16. Fluoride -NHS (2022) NHS choices. NHS. Available at: <https://www.nhs.uk/conditions/fluoride/#:~:text=Toothpastes%20containing%201%2C350%20to%201%2C500,at%20least%201%2C000ppm%20fluoride>
 17. Gengigel (2023) Gengigel - Clinically Proven To Protect and Heal Gum Disease <https://www.gengigel.co.uk>
 18. Ghassemi A, Hooper WJ, Vorwerk LM, Petrovicova E, Goyal CR, Qaqish K, Qaqish JG, Santos S. The effects of two baking-soda toothpastes in enhancing mechanical plaque removal and improving gingival health: A 6-month randomized clinical study. *Am J Dent.* 2020 Oct;33(5):265-272. PMID: 33017530.
 19. Global Market Research Reports

- and Consulting. Oral Care Market Size, Share, Global Trends, Report, 2030.
<https://www.fortunebusinessinsights.com/toothpaste-market-104484>
 Accessed April 2024.
20. Jagtap, M.A. "Preparation and Evaluation of Toothpaste." *Asian J. Pharm. Ana.* 2018; 8(4): 191-194. ajpaonline.com, 2013, ajpaonline.com/HTMLPapers/Asian%20Journal%20of%20Pharmaceutical%20Analysis__PID__2018-8-4-3.html.
 21. Jain N, Dutt U, Radenkov I, Jain S. WHO's global oral health status report 2022: Actions, discussion, and implementation. *Oral Dis.* 2024 Mar;30(2):73-79. doi: 10.1111/odi.14516. Epub 2023 Feb 5. PMID: 36680388.
 22. Jose A, Pratten J, Bosma ML, Milleman KR, Milleman JL, Wang N. Six-Month Evaluation of a Sodium Bicarbonate-Containing Toothpaste for Reduction of Established Gingivitis: A Randomized USA-Based Clinical Trial. *J Clin Dent.* 2018 Mar;29(1):33-39. PMID: 29758155.
 23. Lippert, F. (2013) "An introduction to toothpaste - its purpose, history and ingredients," *Monographs in Oral Science*, pp. 1–14. Available at: <https://doi.org/10.1159/000350456>.
 24. Magaz VR, Llovera BF, Martí M, Garre A. Clinical Impact and Cosmetic Acceptability of Chlorhexidine-enriched Toothpaste and Mouthwash Application on Periodontal Disease: A Randomized Clinical Study. *J Contemp Dent Pract.* 2018 Nov 1;19(11):1295-1300. PMID: 30602630.
 25. Marinho VC, Higgins JP, Logan S, Sheiham A. Fluoride mouthrinses for preventing dental caries in children and adolescents. *Cochrane Database Syst Rev.* 2003;(3):CD002284. doi: 10.1002/14651858.CD002284. Update in: *Cochrane Database Syst Rev.* 2016;7:CD002284. PMID: 12917928.
 26. Mason S, Patil P, Karad V. A Randomised Clinical Study to Evaluate Efficacy on Gingival Health of 62% and 67% Sodium Bicarbonate Toothpastes. *Oral Health Prev Dent.* 2021 Jan 7;19(1):609-618. doi: 10.3290/j.ohpd.b2403125. PMID: 34874138.
 27. Mesa FL, Aneiros J, Cabrera A, Bravo M, Caballero T, Revelles F, del Moral RG, O'Valle F. Antiproliferative effect of topic hyaluronic acid gel. Study in gingival biopsies of patients with periodontal disease. *Histol Histopathol.* 2002;17(3):747-53. doi: 10.14670/HH-17.747. PMID: 12168783.
 28. Mouthulcers (2023) Curasept Mouth Rinse 200ml. <https://www.mouthulcers.co.uk>
 29. Nassar Y; Brizuela M (2024) The Role of Fluoride on Caries








- Prevention NCBI Bookshelf. A service of the National Library of Medicine, National Institutes of Health. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-.
30. Oral-B Gum and Enamel Repair Original Toothpaste (2022) <https://www.oralb.co.uk/>
 31. Parodontax (2023) Toothpaste and Toothbrush for Gum Health. <https://www.parodontax.com>.
 32. Poppolo Deus F, Ouanounou A. Chlorhexidine in Dentistry: Pharmacology, Uses, and Adverse Effects. *Int Dent J*. 2022 Jun;72(3):269-277. doi: 10.1016/j.identj.2022.01.005. Epub 2022 Mar 12. PMID: 35287956; PMCID: PMC9275362.
 33. Pratten J, Wiecek J, Mordan N, Lomax A, Patel N, Spratt D, Middleton AM. Physical disruption of oral biofilms by sodium bicarbonate: an in vitro study. *Int J Dent Hyg*. 2016 Aug;14(3):209-14. doi: 10.1111/idh.12162. Epub 2015 Jul 21. PMID: 26198308
 34. Rajendiran, M.; Trivedi, H.M.; Chen, D.; Gajendrareddy, P.; Chen, L. Recent Development of Active Ingredients in Mouthwashes and Toothpastes for Periodontal Diseases. *Molecules* 2021, 26, 2001. <https://doi.org/10.3390/molecules2607200>
 35. Sabri H, Derakhshan Barjoei MM, Azarm A, Sadighnia N, Shakiba R, Aghebati G, Hadilou N, Kheiri P, Ghanbari F, Deravi N, Mokhtari M. The Yin and Yang of Sodium Lauryl Sulfate Use for Oral and Periodontal Health: A Literature Review. *J Dent (Shiraz)*. 2023 Sep;24(3):262-276. doi:10.30476/dentjods.2022.95108.1836. PMID: <https://doi.org/10.30476/dentjods.2022.95108.1836>. Accessed 4 Oct. 2023.
 36. Sälzer S, Rosema NA, Martin EC, Slot DE, Timmer CJ, Dörfer CE, van der Weijden GA. The effectiveness of dentifrices without and with sodium lauryl sulfate on plaque, gingivitis, and gingival abrasion--a randomized clinical trial. *Clin Oral Investig*. 2016 Apr;20(3):443-50. doi: 10.1007/s00784-015-1535-z. Epub 2015 Aug 22. PMID: 26293981; PMCID: PMC4799265.
 37. Sensodyne Sensitivity Gum & Enamel Toothpaste (2023) <https://www.sensodyne>.
 38. Simmer JP, Hardy NC, Chinoy AF, Bartlett JD, Hu JC. How fluoride protects dental enamel from demineralization. *J Int Soc Prevent Communit Dent* 2020; 10:134-41.
 39. Solanki YS, Agarwal M, Gupta AB, Gupta S, Shukla P. Fluoride occurrences, health problems, detection, and remediation methods for drinking water: A comprehensive review. *Sci Total Environ*. 2022 Feb 10;807(Pt 1):150601. doi:10.1016/j.scitotenv.2021.150601. Epub 2021 Sep 28. PMID: 34597567. www.sciencedirect.com/science/article/pii/S00489697210

- 56795?casa_token=hR4gfwZI518AAAAA:K88SIOqU-CHRFrkJynA6OQ4_PZ_BfJy6bE6iCQSwcFgIG8NTg - 0Gwe81bvy7YvcW0jKs8tEhWA, <https://doi.org/10.1016/j.scitotenv.2021.150601>.
40. Studman A (2022) Toothpaste claims unpicked: is it worth paying more? - Which? News. <http://www.which.co.uk/news/article/toothpaste-claims-unpicked-is-it-worth-paying-more>? - Which? News. Accessed April 2024.
41. Subramanian, S, Appukuttan D, Tadepalli, A, Ponnudurai P, Gnana S et al. The Role of Abrasives in Dentifrices. *J Pharma Sci & Research*. Vol 9(2), 2017, 221-224. Available from: <https://www.researchgate.net/publication/316696976>. The_role_of abrasives_in_dentifrices [accessed Apr 23, 2024].
42. Taschieri S, Tumedei M, Francetti L, Corbella S, Del Fabbro M. Efficacy of 67% Sodium Bicarbonate Toothpaste for Plaque and Gingivitis Control: a Systematic Review and Meta-Analysis. *J Evid Based Dent Pract*. 2022 Jun;22(2):101709. doi: 10.1016/j.jebdp.2022.101709. Epub 2022 Feb 26. PMID: 35718441. Feb. 2022, p. 101709, <https://doi.org/10.1016/j.jebdp.2022.101709>.
43. Triratana, T, Kraivaphan P, Amornchat C, Delgado E, Zhang Y (2014) *Clinical Uwitonze., A.M., et al. "Zinc Adequacy Is Essential for the Maintenance of Optimal Oral Health."* *Nutrients*, vol. 12, no. 4, 30 Mar. 2020, p. 949, <https://doi.org/10.3390/nu12040949>.
44. Vranić E, Lacević A, Mehmedagić A, Uzunović A. Formulation ingredients for toothpastes and mouthwashes. *Bosn J Basic Med Sci*. 2004 Oct;4(4):51-8. doi: 10.17305/bjbm.2004.3362. PMID: 15628997; PMCID: PMC7245492.
45. Wang Y, Jiang L, Zhao Y. Awareness of the Benefits and Risks Related to Using Fluoridated Toothpaste Among Doctors: A Population-Based Study. *Med Sci Monit*. 2019 Aug 26; 25:6397-6404. doi: 10.12659/MSM.918197. PMID: 31447481; PMCID: PMC6727672. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6727672/>
46. WHO The Global Status Report on Oral Health 2022 (who.int) accessed April 2024.
47. Williams C, McBride S, Mostler K, Petrone DM, Simone AJ, Crawford R, Patel S, Petrone ME, Chaknis P, DeVizio W, Volpe AR, Proskin HM. Efficacy of a dentifrice containing zinc citrate for the control of plaque and gingivitis: a 6-month clinical study in adults. *Compend Contin Educ Dent*. 1998;19(2 Suppl):4-15. PMID: 10371876. Toothpaste Marketing Share, Size, and Industry Analysis (2030).



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