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***Review Article***

# RECENT ADVANCES IN DENTIFRICES

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ABSTRACT

Dentifrices are pastes, gels or powders that help remove plaque, a film of bacteria that forms on teeth and gums every day. A great deal of research and development has been undertaken to improve the quality and effectiveness of dentifrices. Modern dentifrices have evolved to become smooth, good tasting toothpastes which contain anticaries, antigingivitis, antisensitivity ingredients, or breath fresheners while providing greater cosmetic and therapeutic benefits. The science and technology underlying the design, composition and manufacture of modern dentifrices have become very advanced from decades ago till today. This review discusses the various ingredients used, their uses, recent advances and future applications of dentifrices.

Keywords: dentifrice, calculus, anti-plaque, anti-caries, hypersensitivity

## Introduction

For centuries, the main use of dentifrices has been associated with cleaning of teeth, removal of unsightly enamel stains, and promoting 'fresher breath.' In the modern era, dentifrices have replaced toothpowders and/or any other aid used for cleaning teeth. Commercial dentifrices, by virtue of their aesthetic properties, are known to promote tooth brushing and thus provide improved dental health. The addition of chemotherapeutic additives to dentifrices can contribute significantly to enhance the health benefits of these products[1]. Since the mid-20$^{th}$ century, a great deal of research and development has been done to improve the quality and effectiveness of dentifrices. This is being achieved by adding a variety of safe, effective and compatible ingredients to dentifrice that may interact chemically with tooth structure, reduce demineralization, promote remineralization and thus have an antibacterial action. The ingredients are so added that they interfere with bacterial adhesion to the teeth, prevent the formation of supragingival calculus, and reduce dentinal hypersensitivity. In view of the present requirement, dentifrices are being designed and targeted for specific user groups. Nowadays, they are being made to provide multiple cosmetic and therapeutic benefits[2]. The science and technology underlying the design, composition and manufacture of modern dentifrices have become very advanced from decades ago till today. Dental professionals are therefore throne with the responsibility to have a better understanding of the technology associated with recent advances in dentifrices so that they can recommend their patients the most appropriate and effective

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dentifrice to use for improved oral health and a better quality of life.

**Ingredients in Dentifrice**

Dentifrice commonly contains the following ingredients:

1. **Abrasives:** These are added to clean the teeth and to remove stains. The cleaning effect of one is combined with polishing effect of another to give the best result. The cleaning power of abrasive depends on the type and amount of abrasive particles, surface it contacts, dilution by saliva and brushing pressure. Commonly used abrasives are silica/hydrated silica, hydrated aluminium oxides, calcium carbonate, brushite and gibbsite.
2. **Water:** It acts as a solvent and dissolves ingredients allowing them to be mixed.
3. **Humectants:** These act as moisturizing agents and protect dentifrice from drying up during storage. They provide a smooth creamy texture to the dentifrice. Among the commonly used substances as humectants are glycerin, sorbitol, propylene glycol and paraffin oil.[3]
4. **Detergent/surfactant:** They act as surface-active substances and decrease surface tension, thereby emulsify and remove debris with their foaming action. Sodium laurylsulfate, sodium lauryl sarcoside, sodium monoglyceride sulfate, ethionates of fatty acid, sodium dodecyl benzene sulfonate and PEG oil (polyethylene glycol oil) are some of the commonly used detergents added to the dentifrice.
5. **Thickening agent/binding agent:** These are hydrophilic colloids which disperse or swell in the presence of water and are used to stabilize dentifrice formulations by preventing the separation of the solid and liquid phases. Eg: natural gums (arabic, karaya and tragacanth), the seaweed colloids (alginates, Irish moss extract and gum carrageenan), synthetic celluloses (carboxymethyl cellulose, hydroxyethyl cellulose), xanthum gum and Carbomer-940 A or Carbomer-956.
6. **Flavoring agent:** Dentifrice would taste pretty bad without the addition of flavoring agents. That is why various natural and artificial flavorings such as mint, peppermint, spearmint and wintergreen and sweeteners such as saccharine, acesulfame K, aspartame and xylitol have been added to them. The humectant sorbitol also adds a sweet taste. However American Dental Association (ADA) does not put its seal on dentifrices that contain sugar or any other ingredient that promotes tooth decay.[4]
7. **Therapeutic agent:** These are active components added to the dentifrice to reduce caries, inhibit tartar formation, help in desensitization and have an antimicrobial and anti-inflammatory action. Some of the commonly used therapeutic agents are fluoride, triclosan, sanguinarine and chlorhexidine.
8. **Coloring agent/Preservative:** Coloring agents provide dentifrice with pleasing colors. Artificial dyes such as FD&C Blue No. 1 are used to make red, green, and blue dentifrices. Titanium dioxide which is not present in gel dentifrices, is used to make some dentifrices white. Preservatives prevent the growth of microorganisms in dentifrice and thus eliminate the need to refrigerate dentifrice. Common preservatives include sodium benzoate, methyl paraben, and ethyl paraben.

**TYPES OF DENTIFRICES**

1. **Anticavity dentifrice:** It contains fluoride to stop enamel decalcification, promote remineralization and thus protects teeth from decay and cavities.

2. **Tartar Control Tooth Paste:** Tartar, sometimes called calculus, is plaque that has hardened on teeth by the deposition of mineral salts (such as calcium carbonate). Proper brushing with tartar control dentifrice can prevent its formation. Main constituents of tartar control tooth paste are pyrophosphate (tetrasodium pyrophosphate), zinc citrate and zinc chloride. They stabilize the amount of calcium in saliva and interfere with the crystalline structure of calculus. They are absorbed into the enamel surface as a calcium complex from which phosphate is freed from the crystal lattice but calcium is not. The calcium rich crystal lattice inhibits the growth of crystals on the enamel surface and thus decreases the formation of tartar.[5]
3. **Desensitizing tooth paste:** Dentine is a mineralized tissue containing many dentinal tubules. These dentinal tubules are filled with fluid and connected with dental pulp. Whenever pressure is applied upon the fluid at the exposed end, it is felt by the pulp causing sensitivity. Desensitizing dentifrice causes occlusion of dentine tubules thus reduces dentine hypersensitivity. Substances used for desensitization of dentine are strontium chloride, formaldehyde, potassium nitrate, potassium chloride and sodium citrate.[6]
4. **Anti-plaque/anti-gingivitis dentifrice**: Antiplaque agents reduce plaque growth. This can have a positive effect in reducing plaque growth on teeth, reducing gingivitis, and potentially reducing caries.[7] Some antiplaque agents include triclosan, papain and sanguinaria extract. Triclosan has been accepted by the FDA as an antiplaque-antigingivitis therapeutic additive to dentifrices.[8,9]
5. **Whitening tooth paste:** They contain special ingredient such as hydrogen peroxide for teeth bleaching and whitening. The peroxides deliver oxygen radicals to enamel. According to the American Dental Association (ADA), because it acts as a bleaching agent, hydrogen peroxide actually changes the color of the enamel on the surfaces of the teeth by cleaning the extrinsic stains that discolor the outside of the tooth. Tooth whitening dentifrices have higher abrasive value than normal tooth paste to remove food, smoking and other stains.[10]
6. **Baking soda tooth paste:** It contains white crystalline powder such as sodium bicarbonate or sodium hydrogen carbonate, which cleans teeth with low abrasive effect, removes extrinsic stains and inhibits plaque attachment to tooth.
7. **Fresh breath dentifrice:** These are the most popular dentifrices in the market. They contain enhanced flavoring agent along with antibacterial agents that help to fight against halitosis. They may also contain aloe vera leaf juice and essential oil of peppermint.
8. **Tooth paste for children:** These kind of modern tooth pastes are specially created for children. They have pleasant flavors and come in attractive colors. These tooth pastes contain no sugars and have low concentration of fluoride (500-1000ppm) to prevent cases of fluorosis.
9. **Natural dentifrice/herbal dentifrice:** Herbal dentifrices are made from natural ingredients and some are certified as organic. These days many consumers have started to switch to natural dentifrices in order to avoid synthetic and artificial flavors commonly found in regular dentifrice. They

don't contain dyes, artificial flavors or chemicals. It is good choice for people who are allergic to mint or to sodium lauryl sulfate, a foaming agent that is included in most commercial tooth paste brands.

10. **Dentifrice containing biometric synthetic hydroxyl apatite:** In 2006, it appeared in Europe as the first dentifrice containing biometric synthetic hydroxyl apatite as an effective alternative to fluoride for the remineralization and repair of tooth enamel. Function of the biometric hydroxyl apatite is to protect the teeth by creating a new layer of synthetic enamel around the tooth instead of hardening the existing layer with fluoride that chemically changes into fluoroapatite.[11]
11. **Striped tooth paste:** Striped tooth paste was invented by Leonard Lawrence in 1955 at New York. The patent was subsequently sold to Unilever, who marketed the novelty under the 'Stripe' brand-name in the early 1960s. The red area represents the material used for the strips and rest is the main paste material. Two materials are not in the separate compartments. They are sufficiently viscous, that they do not mix. Applying pressure to the tube causes the main material to squeeze down the thin pipe to the nozzle. Simultaneously, some of the pressure is forwarded to the strip material which is then pressed on the main material through the holes in the pipe.

**Recent Advancements in Dentifrice**

1. **Enamelon:** It is formulated with stabilized stannous fluoride and optimized with the remineralizing potential of amorphous calcium phosphate (ACP) technology. It provides fluoride as well as calcium and phosphate to teeth which help to strengthen the enamel. The remineralization process is enhanced by converting soluble calcium and phosphate to naturally hydroxyapatite. The amount of fluoride used in the product is substantially less than that found in the usual 5000 fluoride dentifrices currently available. Enamelon contains just 970 ppm fluoride and yet, according to the studies on the product, provides more than twice the fluoride uptake into enamel lesions.[12] It not only reduces the solubility of enamel, thereby preventing caries but also interfere with the harmful effects of plaque associated with gingivitis. The ACP technology helps periodontal patients with exposed root surfaces by relieving sensitivity through tubular occlusion.[13] It also contains Ultramulsion, a patented saliva-soluble coating that moisturizes and soothes oral soft tissues. Ultramulsion may provide improved therapeutic performance by enhancing substantivity. It has a great tasting mint flavor. It does not contain sodium lauryl sulfate (SLS), abrasives, gluten and dyes.
2. **Desensitizing dentifrice:** Bioactive glass called NovaMin is the most recent technology in this category. It was introduced into the dental market as a desensitizer in December 2004. The active ingredient in NovaMin is calcium sodium phosphosilicate. Saliva in the mouth reacts with calcium sodium phosphosilicate present in Novamin to form a protective layer of hydroxyapatite on teeth. This layer creates a barrier that prevents tooth sensitivity. NovaMin containing dentifrice proved more effective than other desensitizing dentifrices containing potassium nitrate and fluoride. According to a study conducted by Burwell A. et al, NovaMin adheres to exposed dentin surface and reacts with it to form a

mineralized layer, occluding dentin tubules and hence decrease hypersensitivity[14].

3. **Calcium phosphate dentifrice:**
   i. **Tooth Mousse:** It is not a dentifrice but a topical tooth créme that helps to strengthen teeth by binding calcium and phosphate to the tooth surfaces, plaque and surrounding soft tissue. It contains RECALDENT (CPP-ACP Casein Phosphopeptide - Amorphous Calcium Phosphate), a special milk-derived protein which maintains saturation of levels of minerals, especially calcium and phosphate, at the tooth surface thereby decreasing demineralization and enhancing remineralization of teeth.[15] It is applied topically to teeth and gums to provide extra protection for teeth and to neutralize acid challenges from bacteria in plaque. Tooth Mousse with RECALDENT (CPP-ACP) has a proven clinical success record for patients with high caries risk and white spot lesions.
   ii. **Clinpro Tooth Crème:** It delivers a unique combination of fluoride, calcium and phosphate, which are components found naturally in saliva. During the manufacturing process, a protective barrier is created around the calcium allowing it to coexist with the fluoride ions. As the dentifrice comes in contact with saliva during brushing, the barrier breaks down and makes the calcium, phosphate and fluoride readily available to the tooth. The tooth naturally absorbs these components, helping to prevent the initiation and further progression of demineralization and allowing remineralization to occur.[16]
4. **OraMD**: It is low-cost, compact liquid dentifrice that uses essential oils and functions as a dentifrice, mouthwash and breath freshener all at once. OraMD is made solely from 100% natural almond, spearmint and peppermint oils. It has no sweeteners, no coarse minerals to erode tooth enamel, no fluoride, no artificial sweeteners, etc. It is not artificial or toxic, unlike other harmful chemicals found in conventional dentifrice products available in market. Even better, these botanical oils of peppermint, spearmint and almond are natural bacteria fighters, meaning they help in maintaining good oral hygiene[17].

## THE FUTURE OF DENTIFRICES

1. **Nanotechnology dentifrice**: Nanotechnology deals with the physical, chemical, and biological properties of structures and their components at nanoscale dimensions.[18] Nanodentistry is defined as the science and technology of diagnosing, treating and preventing oral and dental diseases, relieving pain, and of preserving and improving dental health, applying materials structured on the nanometer scale.[19] Nanodenstistry can consist of natural tooth maintenance which would be the appearance. The durability of the tooth would be improved by replacing enamel layers with sapphires or diamonds since diamonds are 100 times harder than regular tooth enamel. With the use of this technology, it can lead to a whole new future of Nanodentistry. There will be the use of nanorobots that will interact with the human body to clean the teeth. These devices

would also identify food particles, plaque, or tartar, and lift them from teeth to be rinsed away.[20]

2. **Coconut might make the perfect dentifrice of the future:** In Ireland researchers of Athlone Institute of Technology (AIT) have found that growth of harmful bacteria can be inhibited effectively by coconut oil and thus can prevent tooth decay and oral infections. Coconut oil not only helps protect the teeth against bacterial decay, but also helps to improve digestion and metabolism and strengthen immunity. Since ingesting coconut oil converts it into a powerful bacteria-fighter, "swishing" coconut oil can also promote improved oral health via the enzymatic activity of its mixing with saliva. Incorporating enzyme-modified coconut oil into dental hygiene products would be an attractive alternative to chemical additives like fluoride.[21,22]
3. **Solar toothbrush of the future may replace dentifrice:** The solar toothbrush works by releasing electrons that react with saliva in the mouth and help to breakdown plaque. According to the manufacturers, the solar toothbrush will remove plaque even if dentifrice is not used; meaning that if the innovation ever catches on, it could shake up the oral care industry.[23]
4. **Weather dentifrice:** The dentifrice is called "Tastes Like Rain". A little computer is dispensed which checks the internet for the day's weather, and mixes together several different flavors of dentifrice accordingly. If it's going to be warmer than yesterday, one will get a higher proportion of cinnamon dentifrice, and if it's going to be cooler, one will get more mint. A blue stripe means it's going to rain.[24]
5. **Dentifrice in tablet form:** There is a new innovation in the world of dental disposables that will help to prevent the spread of germs. A concern for many households is that bacteria can be transferred from the brush to the tube, so various cold and flu are more likely to spread, when the dentifrice is shared between members of the family. These tablets prevent this as they provide just enough cleaning product for one use. This also helps to prevent wastage, as one cannot accidentally squeeze out more than he actually need for a good clean.[25]
6. **The £10 dentifrice that can 'rebuild' teeth:** Unilever has unveiled new dentifrice (Regenerate) and it claims can regenerate 82per cent of tooth enamel after just three days of use. The company claims this has the effect of restoring teeth to their original whiteness while making them much stronger, which means they are less likely to develop cavities. The technology requires the use of a 'Boosting Serum' treatment, which is applied using two custom-fit mouth trays. The two key ingredients in the dentifrice are calcium silicate and sodium phosphate.[26]

**Conclusion**

With many different types of dentifrices in the market and manufacturers constantly searching for the all-in-one dentifrice, consumers and dental professionals need to know how to find a product that matches their needs. Understanding the active and inactive ingredients, assessing claims and efficacy and considering disease indicators and risk factors, all play a major role in deciding which dentifrice can best deliver the desired benefits, safely and effectively.

**Conflict of Interest**

The author(s) state that there has been no conflict of interest and no funding/promotion of any particular product has been made through this review article.

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