DENTIFRICES: ITS COMPOSITION, FORMS AND FUNCTION - A LITERATURE REVIEW

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ABSTRACT

Due to extended knowledge of the dental caries process, its prevention has been greatly advanced over the past fifty years, it is fair to state that the management of this disease at the level of the individual patient remains largely empirical. Recent innovations in oral care products have been directed toward making cosmetic marketing claims. There continues to be a need for innovation and collaboration with other scientific disciplines to fully understand and prevent dental caries.

Keywords: Abrasive, Caries, Dentifrices, Toothbrush

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INTRODUCTION

For centuries the main uses of dentifrices were related to cleaning the teeth, removal of unsightly enamel stains and promoting fresher breath. Today toothpastes represent by far the most commonly manufactured preparation which is used, in conjunction with the tooth brush, for affecting the accumulation, removal and the metabolic activities of dental plaque.[1]

As with time people are more concerned in relation to dental problems there should be processes to increase effectiveness and functionality of toothpaste, which is being achieved by adding a variety of safe, more biologically active yet compatible ingredients that may interact chemically with tooth structure, reduce demineralization, interfere with bacterial adhesion to the teeth, provide antibacterial action, prevent the formation of supragingival calculus, promote remineralization and reduce dentinal hypersensitivity.[2]

It is a complex process to design and produce clinically effective, multifunctional toothpastes which should satisfy all basic concerns, including safety, optimal rheology, pleasant flavor, packaging, shelf life and acceptable cost. Beyond that, the ultimate goal is to ensure that the toothpaste ingredients designed to accomplish each specialized function will remain compatible in a combined or final formulation[3,4]. The anti-plaque, anti-gingivitis and anti-calculus benefits of modern toothpastes also are also likely to be contributing factors to the retention of the natural dentitions.[2] Thus in the best interests of the public, dentists should be fully equipped with a body of knowledge about dentifrices so as to be able to advise their patients to make evidence based choices with regard to the most appropriate and effective toothpaste to use for improved oral health and a better quality of life.

DISCUSSION

Dentifrices are agents used along with toothbrush to clean and polish natural teeth. They are supplied as paste, powder, gel or liquid form. The most essential dentifrice recommended by dentists is toothpaste which is used in conjunction with a toothbrush to help remove food debris and dental plaque.[5]

Forms of Dentifrices

Toothpaste[6]

Toothpastes are products to be used with the toothbrush, that comprise ingredients to enhance the basic plaque removing functionality of the toothbrush and provide additional benefits, i.e., cavity reduction, breath freshening, removal of dental stain, overall oral cleanliness and delivery of therapeutic agents. Toothpaste is semisolid in consistency and flows slowly. The essential components are abrasives, binder, surfectants and humectants. A paste is essentially a thick, soft, moist substance typically produced by mixing dry ingredients with a liquid.

Gel form [7]

Gels are defined as a substantially dilute cross-linked system, which exhibits no flow when in the steady-state. Gel form toothpastes consist of abrasives, binders, surfectants, humectants and flavouring agents. Gel is composed of silica rather than calcium carbonate as an abrasive and also include fatty acids.

Tooth powder[5]

Tooth powder is an alternative to toothpaste which is available in both fluoride and non-fluoride version. Tooth powder is a mildly abrasive powder which is used in combination with a toothbrush to maintain oral hygiene. The primary ingredient in a tooth powder is, of course, an abrasive to lift plaque and food from the teeth. Baking soda is a common abrasive, along with salt or chalk. A soap may be included to encourage the tooth powder to foam. A tooth powder may also include antibacterial ingredients like tea tree extract, or a flavoring agent such as mint to make it more palatable.

Liquid dentifrice [8]

Liquid dentifrices have advanced physical properties and are more efficient than other forms of dentifrices in reaching interproximal areas and other inaccessible areas of the dentition.

Composition of Dentifrices

Dentifrices are generally a mixture of an abrasive or polishing agent, detergent, binders, flavoring agents and substances necessary to facilitate their preparation and use. Therapeutic dentifrices contain, in addition to the above, one or more chemicals intended to reduce the incidence of oral dental diseases. More recently gel dentifrices have appeared in the market that contain the same components as the toothpastes, with the exception that the gels have a higher proportion of the thickening agents.[9]

Dentifrice Ingredients

Dentifrices contain both active and inactive ingredients. Active ingredients are those that offer a therapeutic benefit, while inactive ingredients are non-therapeutic and also contribute to the physicochemical properties of the dentifrice - its feel, consistency, sweetness, flavor, pH, texture, abrasiveness and appearance.[9,10]

Active Ingredients[5,9]

Active ingredients helps in prevention of caries, sensitivity, plaque/gingivitis, calculus formation and halitosis. The first active ingredient included was fluoride.

Active ingredients and their functions

Anti-caries: Sodium fluoride, Sodium monofluorophosphate, Stannous fluoride, Amine fluoride, Xylitol

Anti-plaque/anti-gingivitis: Triclosan/ copolymer, Stannous fluoride, Zinc citrate

Anti-calculus: Tetrapotassium pyrophosphate, Tetrasodium pyrophosphate, Sodium hexametaphosphate, Zinc compounds, Triclosan/ copolymer.

Anti-halitosis: Essential oils, Chlorine dioxide, Triclosan/ copolymer, Stannous fluoride/sodium hexametaphosphate
Desensitizers: Potassium citrate, Potassium nitrate, Potassium chloride, Stannous fluoride, Strontium chloride.

Anti-apthous agents: Aminoglucosidase, Glucose oxidase.

Inactive Ingredients [9]

Inactive ingredients in dentifrices include binders, abrasives, surfactants, buffering agents.

Abrasives[2,11,12]

Functions

1. Removal of debris and residual stains
2. Abrasives are used in dentistry for abrading, grinding and polishing
3. Abrasives affect the consistency of the toothpastes

The degree of abrasivity depends on the hardness of the abrasive, the morphology of the particles, and on the concentration of abrasive in the paste. Abrasives usually do not damage enamel, but may dull the tooth lusture. To compensate for this, polishing agents are added to the dentifrice formulations. These polishing agents are usually small sized particles of aluminum, calcium, tin, manganese or zirconium compounds. Agents such as chalk or silica may have both polishing and abrasive effects.

E.g. **Phosphates**:

- Dicalcium phosphate dehydrate
- Calcium pyrophosphate

Carbonates

- Sodium bicarbonate
- Calcium carbonate

As the abrasive level increases, greater care must be taken to perfect brushing techniques that do not cause self-inflicted injury to their teeth or soft tissues. The safe limits for an abrasive in a toothpaste according to the British Standards Institute is:

- Substrate - Abrasivity limit
- Dentin - Twice that to standard toothpaste.
- Enamel - Four times that of standard toothpaste

Humectants[13]

Humectants are moisturizers and also provide smooth texture to the toothpaste. Proper usage levels produce a clear translucent toothpaste. Humectants were added to maintain the moisture. These humectants are nontoxic but mold or bacterial growth can occur in their presence, for this reason, preservatives such as sodium benzoate are added. Eg. Glycerin (99.5%) and sorbitol (70%), Polyethylene glycol, Xylitol and Propylene glycol.

Binders[7]

Binders are hydrophilic colloids which disperse or swell in the presence of water. Humectants help to maintain the consistency of toothpaste, but despite their presence, the solids tend to settle out of the paste. To counteract this, thickening or binding agents are added to the formula.

Eg. **Natural polymers:** carboxy methyl cellulose, carageenans and Xyntholgum, Synhethic polymers, Gums.

Surfactants/ Detergents [7,14]

Detergents are cleansing or purging agents that through a surface action that depends on their possessing both hydrophilic and hydrophobic properties, exerts cleansing (oil-dissolving) and antibacterial effects. Sodium lauryl sulphate (SLS) is the most commonly used detergent. It is stable, possesses some antibacterial properties and has a low surface tension, which facilitates the flow of the dentifrice over the tooth surface.

Eg. Sodium lauryl sulphate, Sodium N lauryl sarcosinate, Sodium dodecyl benzene sulphonate, PEG.

Flavoring Agents[5]

Flavor, along with smell, colour and consistency of products is an important characteristic that leads to public acceptance of dentifrice. The flavoring agents are solubilized and dispersed through the paste or liquid via the detergent.

Eg. Peppermint, spearmint, wintergreen modified with other essential oils of aniseed, clove, caraway, eucalyptus, citrus, menthol, nutmeg, thyme or cinnamon.

Sweeteners[9]

Saccharin, cyclamate, sorbitol and mannitol serve as primary non cariogenic sweetening agents;the latter two also serve as humectants. A new sweetener in dentifrice is xylitol. It demonstrated an anticaries capability by facilitating the remineralisation of incipient carious lesions.

Eg. Sodium saccharin, Sodium cyclamate, Acesulphame K.

Preservatives[5]

Preservatives prevent the growth of micro-organisms in the toothpaste. Microbial contamination of dentifrices is restricted by a low water activity and by the inclusion or preservatives such as benzoates. E.g. Sodium benzoate, Methyl paraben, Propyl paraben.

Coloring Agents[15]

The colour-substances are classified by the Colour Index (CI), published by the Society of Dyers and Colourists and the American Association of Textile Chemists and Colourists, or by a system called the F D & C Colours. Titanium dioxide is often added to toothpastes to give them a white, opaque colour.

Eg. Titanium dioxide, Various food dyes for coloured pastes and gels.

Solvents[7]

Water is the most common solvent used in toothpastes which helps in dissolving ingredients and allows them to be mixed. Manufacturers are required to list all the ingredients present in toothpaste however most manufacturers do not reveal all the ingredients as it is a trade secret for them.

Functions of Dentifrices

Various functions of A multifunction toothpaste are[16]

1. Chemotherapeutic prevention of bacterial biofilm and gingivitis.

2. Preventing and controlling calculus

formation

3. Tooth whitening by prevention and reduction of extrinsic stains
4. Controlling breath malodor with toothpastes
5. Dentifrices in caries control
6. Dentifrices for the treatment of dentine hypersensitivity

1. Chemotherapeutic prevention of bacterial biofilm and gingivitis[2,17,18]

Dentifrice is a logical vehicle to introduce appropriate antibacterial and effective non-antiseptic agents to intervene against microorganisms as well as extracellular matrix that forms and constitute the harmful biofilm on the teeth. Populated with acidogenic and aciduric microorganism, bacterial biofilm on the teeth (dental plaque) is a key etiological contributor to the undesirable dental conditions: Dental caries, gingivitis and its sequels and calculus formation. Significantly controlling and reducing the dental biofilm would ameliorate all three conditions.

The strongest antibacterial agent identified is the bisguanide antiseptic chlorhexidine's gluconate, which inhibits bacteria by disrupting their cell wall causing leakage from the bacterial protoplasm. In contrast, divalent metal ions compounds ,stannous fluoride and zinc citrate as well as non ionic antiseptic, triclosan have all found their way into numerous dentifrice formulations, and all three have been effective in the clinical setting with respect to bacterial biofilm control and gingivitis prevention. Stannous fluoride in a newly stabilized form has returned to toothpaste as both an anti caries and as an anti plaque and anti gingivitis agent. Zinc citrate containing toothpastes have been formulated to include .3% triclosan.

These formulations have shown good anti plaque and anti gingivitis efficacy.

Toothpaste formulated with triclosan and a copolymer of polyvinyl methyl ether and maleic acid (gantez) have consistently demonstrated good efficacy in both dental plaque prevention and gingivitis reduction.

2. Preventing and controlling calculus formation [19,20]

Several agents that are well known as crystal growth inhibitors including pyrophosphates, diphosphotases, hexametaphosphate, zinc citrate , zinc chloride and gantrez acid among others.

Agents for calculus formation

- Pyrophosphates
- Diphosphonates
- Polyphosphates
- Hexametaphosphates
- Zinc citrate
- Zinc chloride
- Gantez acid

All of these agents have found their way into modern dentifrices and in clinical trials conducted till date have consistently exhibited clinically relevant reductions in calculus formation. Calculus reduction percentages obtained in these studies ranged from 5 to 5 0%.

White made an interesting point that in the 1970s there was considerable concern that agents interfering with mineral nucleation to prevent calculus formation might also be expected to diminished remineralization of early caries lesion, as per the dimineralisation-remineralisation model then emerging to explain the dynamics of caries initiation and prevention. Careful attention to this issue indicated that the daily renewal of fluoride from the dentifrice to plaque fluid on the enamel surface "reversed the negative effects of inhibitors of remineralisation".

3. Tooth whitening by prevention and reduction of extrinsic stains [21,22,23,24]

Dentifrices can be formulated to provide a measure of tooth whitening through their potential of preventing extrinsic stain formation or by effecting the removal of extrinsic stain from tooth enamel. Extrinsic stains on enamel are generally the result from adsorption of chromagens to salivary pellicle film existing on the teeth. Chromagens most typically come from dietary products such as tea or red wine, from preparations containing certain metallic salts and also from tobacco

use. In general, focusing on improved tooth brushing habits and combining that with a modern whitening dentifrice is a conservative and tooth friendly first option in seeking to control and diminish dental stain, extent and intensity.

Agents formulated in dentifrices for preventing and/or removing extrinsic stains Three groups of agents that may be formulated into dentifrices for the purpose of preventing and/or removing extrinsic enamel stains are abrasive and chemical and bleaching agents.

Abrasive Agents: Dicalcium phosphate dehydrate, Calcium pyrophosphate, Calcium carbonate, Hydrated silica Chemical Agents: Surfactants(eg SLS), EDTA, Citrates, Pyrophosphates, Polyphosphates.

Bleaching Agents: Hydrogen peroxide, Carbamide peroxide.

Dentifrices relying on abrasive systems for extrinsic stain prevention or removal will generally employ a mixture of a abrasive materials to form an abrasive system an example of such a system is one where a certain quantity of perlite has been added to the main abrasive agent being used. Perlite abrasive enhancement appears to have achieved clinically superior extrinsic stain removal.

Dentifrices relying on chemical agents for stain prevention or removal will usually incorporate elected compounds from a test that includes surfactants, enzyme system, edta, citrates, pyrophosphates, diphosphonates and polyphosphates. Currently only a few dentifrices rely on bleaching ingredients to counteract the stain trapped on the salivary pellicle and enamel surfaces.

4. Controlling breath malodor with toothpastes [7,25]

Halitosis is an oral health concern for many individual. Conscientious and regular oral hygiene is basic to the prevention and control of breath malodor. In recent year dentifrice manufacturers have evaluated methods to incorporate breath freshening technologies in their formulations. In the main, it relies on incorporating one or a combination of the following four constituents in toothpaste:

a) Essential oils for stronger flavours.

b) Zinc and stannous salts as antibacterial agents

c) Triclosan as an antibacterial and

d) Higher levels of sodium bicarbonate as part of the abrasive system.

5. Dentrifrices in caries control 26

Abrasives which are major constituents of dentifrices, contribute minimally to plaque removal and thus to caries reduction. Plaque removal efficacy depends on efficient brushing, not on whether a dentifrice is used or not. The caries inhibitory effect of fluoride is documented for dentifrices containing any of the three fluoride compounds-sodium fluoride, sodium monofluorophosphate and stannous fluoride. Other fluoride compounds such as amine fluoride have also proved to reduce caries development.

6. The role of fluoride in caries reduction [26,27]

Fluoride dentifrices have an indirect effect on the bacterial flora. Fluoride levels down to 2 to 5 ppm fluoride has been shown to reduce lactate and acetate formation. This may reduce the advantage of aciduric bacteria in acidic environments and may theoretically impede the emergence of an aciduric flora.

7. Dentrifices for the treatment of dentine hypersenstivity [28,29,30]

The term 'dentine hypersensitivity' has come into use to describe the condition in which sharp pain is produced in response to mild stimuli which disappears when stimulus is removed. Sensitivity in young adults is probably caused in many cases by consumption of acid diets which causes erosion of thin cervical enamel and thereby exposes dentine.

Incidence of sensitive dentine diminishes with advancing age. Apart from age changes in dentine and pulp which might reduce sensitivity, the proportion of dentate patients also decreases with age. Most frequently affected teeth from sensitivity are premolars, incisors and canines.

Specific dentifrices designed to combat dentinal or cervical hypersensitivity have existed for several decades. These pastes were formulated empirically, offering lower abrasivity and containing a variety of active

ingredients.These agents had three aims:

- Mineral salts(e.g., strontium chloride, potassium oxalate, stannous fluoride) occluded the dentinal tubules
- Occluding the tubules using protein precipitants (formaldehyde and glutaraldehyde)
- Desensitising nerve fibres in the dentinal tubules (potassium nitrate)

Desenitizing agents used in dentifrices: Strontium acetate, Strontium chloride, Formaldehyde, Potassium nitrate, Potassium chloride and Sodium citrate.

CONCLUSION

Dentifrice was originally used to promote oral hygiene by cleaning teeth. Currently over-the-counter (OTC) dentifrices offer various preventive, aesthetic and treatment benefits. While some dentifrices offer only cleaning benefits together with fluoride for anti-caries benefits, in recent years dentifrices with multiple benefits aimed at offering solutions to as many potential problems as possible have been introduced. Recommendations should be based on an individual patient's specific needs and desires as well as the scientific support for a dentifrice Dental education through its various media and even at chairside is an important tool in raising awareness for this simple and relatively inexpensive method of controlling dental diseases.

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