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TOOTHPASTES COMPOSITION AND THEIR ROLE IN ORAL CAVITY HYGIENE

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Abstract

Toothpaste formulas have evolved over time. Today they contain about 20 ingredients. Toothpastes normally contain: active ingredients, abrasives, surfactants, gelling agents, buffers, flavors and sweeteners, dyes and preservatives, water, moisturizers. Among these ingredients are compounds that fight and prevent the appearance of carious lesions, gingival diseases, halitosis, calculus, dental erosions, staining and dentinal hypersensitivity. Herbal toothpastes, which contain natural antibacterial agents, are a good alternative to reduce the risk of oral conditions in both children and adults.

Keywords: *Toothpaste, Active ingredients, Prevention, Antibacterial*

Introduction

Toothpastes are probably the most complex oral care products. They are in the form of a paste, gel, foam or powder, used to maintain and improve oral and aesthetic health.

Each ingredient has a specific function, and together with the other substances found in toothpaste contributes to increasing its effectiveness.

The exact composition of each toothpaste differs depending on the manufacturer, but the classic formula is represented by Abrasive substances 10-40%, Moisturizers 20-70%, Water 5-30%, Gelling agents 1-2%, Detergents 1-3%, Flavors 1-2%, Preservatives 0.05-0.5% and Therapeutic Agents 0.1-0.5%.[1]

The components of the classic toothpaste are found in Fig. 1. To these components there are added active substances in the formula of each toothpaste.

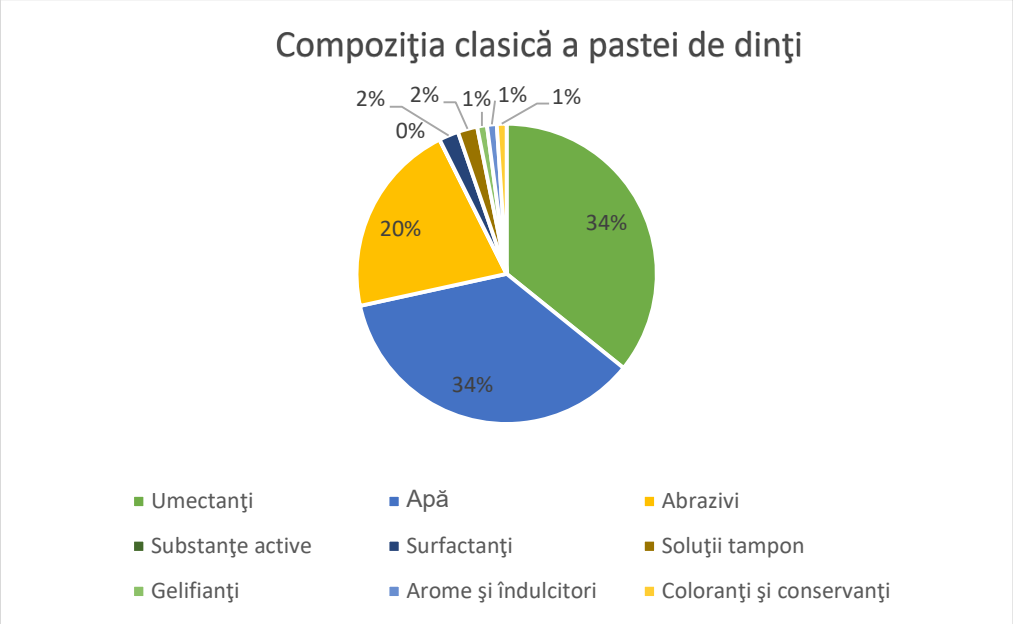

Fig. 1 The components of the classic toothpaste

I. ACTIVE SUBSTANCES

Toothpastes usually contain one, or more, therapeutic substances. The majority of them contain fluoride to prevent cavities. Over time, toothpastes with specific actions have developed, therefore substances with therapeutic actions are nowdays numerous.

1. Fluorides

In 1914, one of the most important discoveries regarding toothpaste took place, namely the introduction of fluoride into the toothpaste formula. It was not until 1960 that the ADA approved the use of fluoride salts.[2]

It is widely accepted that regular use of fluoride, from various sources, is extremely effective in preventing carious lesions.[3]

The appearance of carious lesions is the result of a series of demineralization / remineralization cycles after which, over time, the demineralization conditions predominate. One of the most effective methods of preventing carious lesions is to promote remineralization and slowing down demineralization with fluoride.[4]

Thus, in the presence of Fluorine, at the level of the dental biofilm, the demineralization is reduced due to the fact that the biofilm fluid is supersaturated in terms of Fluorapatite (FA) and the reprecipitation of minerals at the level of the enamel is performed.[5]

Thus, fluorides diminish the risk of carious lesions and can help remineralize the enamel. Currently there are several formulas that contain fluoride, the fluorinated component of toothpaste can be represented by: Sodium Fluoride, Stannous Fluoride, Amine Fluoride with Stannous Chloride, Sodium Monofluorophosphate, Aluminum Fluoride, etc.

The efficiency of fluoride toothpastes is directly dependent on the concentration of fluoride found in each toothpaste. There are formulations without fluoride or formulations with very high concentrations of fluoride, up to 5000 ppm. All formulas that cointain more than 1500 ppm Fluoride should be dispensed only on prescription and only for ages 10 and older, and also used in specific clinical settings.[6]

Depending on the specific legislation of each country or region, several fluorinated compounds can be used in different concentrations. In the EU, fluorinated compounds are regulated as cosmetics, and a total of 20 such compounds are allowed. It is permitted to mix several fluorinated compounds, with the condition that they provide a maximum concentration that does not exceed 1500 ppm of fluorine.

Cel mai des întâlnite sunt:

a. Sodium Fluoride (NaF)

This is a fluoride salt normally used in toothpastes and mouthwashes. Sodium fluoride provides a highly reactive fluoride ion and its formulation with a compatible abrasive is extremely important (silicon abrasives).[7]

b. Stannous Fluoride (SnF_2)

It first appeared successfully in the formula of a toothpaste in 1950, offering as benefit the protection against cavities. The challenge was to find an abrasive system with sufficiently low reactivity with fluoride to succeed in maintaining the bioavailability of fluoride. The successful formula included 0.454% Stannous Fluoride and, as an abrasive, Calcium Pyrophosphate, was marketed as Crest® with Fluoristan®. It was not until the 1990s that manufacturers developed methods to stabilize the formula with Stannous fluoride, which also offered the added antibacterial benefit to the prevention of carious lesions.[8]

*c. Sodium monofluorophosphate (*MFP)

Sodium monofluorophosphate is odorless, colorless and soluble in water. The usual MFP content in toothpaste is 0.76% and is used to replace the Sodium Fluoride, especially in baby toothpastes.
[9]

1. Clorhexidine (CHX)

This is a cationic bisbiguanide with high antibacterial activity that acts by disrupting the bacterial cell membrane, increasing permeability and resulting in cell lysis. Depending on the concentration / dose, its action varies from bacteriostatic to bactericidal. It acts on both gram-positive and gram-negative bacteria, viruses and fungi, and also neutralizes periodontal agents such as Porphyromonas Gingivalis or Prevotella Intermedia. Thus, CHX plays a key role in dentistry and has earned the eponym of "**Gold Standard**" .[1]

It is available in 3 forms:

a) Dicluconate - the most commonly used, water-soluble
b) Acetate - Soluble in water
c) Hydrochloride salts - slightly soluble in water

Three possible mechanisms for plaque inhibition by Chx are suggested:

1. Effective blocking of acidic salivary glycoportein groups that reduces their absorption to hydroxyapatite and the formation of acquired films.
2. The ability of bacteria to attach can be reduced by adsorption of Chx to their additional cellular or glycocalic polysaccharides.
3. Chlorhexidine can compete with the agglutination factors of calcium ions within the bacterial plaque.[11]

It is more effective when used for preventive purposes than when used for therapeutic purposes.[12]

As side effects, we can mention: the burning sensation of the mucosa, the dryness of the mucosa, the epithelial desquamation, the staining at the level of the dental units, the increase of the plaque and calculus at the supragingival level and the temporary change of the taste.[12]

As a limitation, chlorhexidine prevents the formation of plaque, but does not allow its effective removal [17], and used in the composition of the toothpaste, it reacts with

the surfactants present in the toothpaste and reduces their activity.[12]

2. Sodium Bicarbonate

It belongs to the category of abrasive substances in the composition of toothpaste, but has demonstrated abilities to reduce pathogenic microbial flora and attenuate oral pH.

It is also known as baking soda, bicarbonate or carbonic acid monosodium salt. It was first recommended as a component of dental powder by Dr. Jules Sarrazin in 1911, due to its ability to polish dental surfaces without causing dental abrasion or damage to the gums.[13]

Baking soda has been found to be compatible with sodium fluoride and possesses both mechanical and biological mechanisms of action, which can directly influence the Stephan Curve and, therefore, prevent carious lesions through the buffer capacity that will allow pH to return to normal if applied shortly after ingestion of carbohydrates.[14]

Also, it has a direct effect in increasing the level of bicarbonate in the streptococcal plaque, which allows to maintaine a pH level above the critical level during exposure to sucrose.[15]

Bacterial tests showed that Streptococcus Mutans was significantly more susceptible to toothpaste containing baking soda compared to toothpastes with sodium fluoride or stannous fluoride without baking soda. The bactericidal effect was maintained even after pH adjustment by bicarbonate.[16]

3. Metal-ions

The most used metal ions in toothpastes are: Zinc (Zn^{2+}) and Stannous (Sn^{2+}). These metals have the ability to inhibit some bacterial enzymes, limit bacterial growth, inhibit plaque formation and the glycolytic sequence of oral anaerobic bacteria, and restrict the ability of bacteria within the bacterial body to convert urea to ammonia. It is also possible that they reduce the ability of bacteria to colonize dental surfaces.[17]

a. Stannous-Ions.

They are found in toothpaste formulations in the form of Stannous Fluoride or Stannous Pyrophosphate. It has bacteriostatic and bactericidal action, by inhibiting the subsequent activity of the bacterial enzyme in the glycolysis of bacteria. Stannous ions in combination with fluoride are used both to inhibit the demineralization of dental hard tissue and to prevent inflammatory processes caused by bacteria.[17]

b. Zinc-Ions

Zinc is an essential trace element, ubiquitous in all life forms. In the oral cavity it is found in saliva, bacterial plaque and enamel hydroxyapatite. It has been recognized for its antimicrobial properties.[18,19]

Zinc-based toothpastes have an effect on reducing bacteria in the oral biofilm, preventing and controlling plaque, gingivitis and halitosis, and preventing the formation of calculus.[18]

Zinc is found in toothpaste formulations in the form of Zinc Chloride or Zinc Citrate. Toothpastes containing fluoride and zinc have been shown to be more effective in preventing demineralization and promoting remineralization, compared to those containing only fluoride.[19]

4. Essential oils / Natural ingredients

Essential oils (menthol, eucalyptol) are thought to have antibacterial activity through changes in the bacterial cell wall, significantly reducing bacterial plaque and gingivitis.[20] Essential oils have been used for a long time as antibacterial agents.[21]

Herbal toothpastes, which contain natural antibacterial agents, are a good alternative to reduce the risk of oral conditions in both children and adults.

Thyme has antibacterial, antiviral, antioxidant and antifungal effects.[21]
Clove oil has antibacterial activity, prevents the development of gram-positive and gram-negative bacteria, antiviral and antifungal activity.[21]
Propolis has a wide pharmacological potential, antibacterial, antifungal, antioxidant, anticancer, antiviral, anti-inflammatory with liver protective properties.[22]

5. Enzymes: Aminoglycosidase and Glucose Oxidas

The salivary components represented by enzymes and proteins, contribute to the protection against pathogens and contribute to the modeling and control of the resident community. To enhance the role of natural salivary defense in the control of the oral microbial community, oral hygiene products containing enzymes and proteins have been developed.[23]
The most clinically effective enzymes have amyloglucosidase and glucose oxidase as active ingredients.
This results in a reduction in the accumulation of bacterial plaque and, therefore, a reduction in gingival inflammation.[24]

6. Arginine

L-arginine is a unique, semi-essential amino acid, composed of proteins and peptides, with several facets, playing independent roles in the control of biofilm. Also, it influences the physiological processes within the oral cavity and prevents dental diseases. It has a direct influence in the prevention of carious lesions by altering the metabolism of bacterial plaque and compounds.[25,26]
The development and stability of biofilm communities depends on interbacterial communication systems. Arginine disrupts these interactions between cells in the dental biofilm and reduces the mass of pathogenic bacteria. It has not shown bacteriostatic or bactericidal properties, but it destabilizes the biofilm, depending on the arginine concentration.[27]
The role of exogenous L-arginine is to modulate the metabolism of bacterial plaque and increase its pH by producing ammonia. This is produced by resident arginolytic species within the oral biofilm.
L-arginine has been shown to disrupt and destabilize the integrity of biofilm.[28]
Higher concentrations (i.e. 2% / 4%) of Arg in 5% NaF varnish have the potential to modulate the biochemical composition of the biofilm that develops at the level of the treated enamel.[29]

II. TOOTHPASTE EXCIPIENTS

1. Abrasive Substances

The need to introduce abrasive substances in the toothpaste content has been recognized since antiquity, using over time various materials, including pumice stone, bone ash, marble dust, shells and corals, to remove food debris. and extrinsic stains on the teeth.
Normally, the contents of the toothpaste, in order to ensure a good mechanical cleaning, need 3 elements: An abrasive agent, A thickening agent (keeps the abrasive agent in suspension during hygiene prcocedures) and A surface active agent (to effectively remove oral debris) .[1]

Abrasive substances are insoluble substances, this category including Silica, Metal Oxides, Phosphates, Carbonates and Silicates. Some of the abrasives currently used include hydrated silica, hydrated alumina, calcium carbonate, dicalcium phosphate dihydrate, calcium pyrophosphate, sodium metaphosphate, perlite, nanohydroxyapatite, diamond powder and baking soda.[3] They must

be effective in cleaning, with a reduced effect of tooth wear over time. The design of toothpaste abrasive systems is complex and dependent on a variety of properties of the abrasive agent: Chemical composition, Crystalline structure, Cleavage, Friability, Hardness, Concentration, Shape, Size distribution, Particle surface characteristics. [2]

An equally important aspect is the compatibility of the abrasive agent with the other components of the toothpaste, especially with the active substances (mainly fluorides), and the demonstration of acceptable formulation properties (viscosity, texture), without compromising the important attributes for consumer (taste, appearance).

Given the different properties of each abrasive agent and the dedicated clinical application of each toothpaste, their amount varies in each formula. [5]

The most common abrasives, Hydrated Silica and Calcium Carbonate, can be found in a proportion of 8-20%, alumina and perlite, in lower concentrations, 1-2% due to their higher abrasiveness compared to enamel. For the least abrasive it is allowed a much higher concentration, often exceeding 50%. [7]

a. Calcium Carbonate

It is a fine, white, odorless, microcrystalline powder, practically insoluble in water.

This abrasive has been used for a long time. Its abrasiveness is generally higher than that of calcium phosphate. There are two types - a heavy type and a precipitated one.

The raw material for the heavy type is limestone and for the precipitated type it is calcium hydroxide.[6] It binds to Sodium Fluoride and as a resut, a part of it becomes ineffective as an anticaries agent, even if the toothpaste is formulated with Sodium Monofluorophosphate (MFP).[6]

b. Calcium Phosphate

It is available in dihydrate or anhydride form. The anhydrous form is harsher. The dihydrate form has a slight abrasive effect and feels good to use. It has a neutral pH and has a good compatibility with other ingredients. However, when it is in the toothpaste for a long time, it loses its water of crystallization, changes to the form of anhydride and makes the toothpaste harsh. For this reason, a magnesium salt or other stabilizer is added. [6]

c. Silica

Silica is suitable for use in the composition of fluoride-containing toothpastes because it does not form an insoluble salt when reacted with it. It can also be used in the composition of clear toothpastes in the form of gel, because its refractive index is lower than the index of other abrasive substances.[30]

d. Other abrasive substances

As an alternative to dibasic Calcium Phosphate, Aluminum Hydroxide is also used, the latter being cheaper. Other types of abrasives, such as Calcium Pyrophosphate, Insoluble Sodium Metaphosphate, Magnesium Carbonate, can also be used.[30]

2. Surfactants

The foaming agents have the function of dispersing the toothpaste in the oral cavity, in order to increase the cleaning effect, acting as a surfactant.

Surfactants have excellent foaming, dispersing, suspending, permeability and cleaning qualities. They lower the surface tension of the liquid medium in the oral cavity, so that

the substances in the toothpaste can contact the teeth more easily, penetrating and dissolving the bacterial plaque. Another function of them is the dispersion of flavors in the toothpaste. The most commonly used at the moment is Sodium Lauryl Sulfate (SLS) .[2]

Sodium lauryl sulfate Several studies claim that a content of SLS in toothpaste can cause irritation of the skin and mucous membranes, can damage the mucosal mucin layer by glycoprotein denaturation, so these toothpastes would not be suitable for all age groups. , especially for the elderly because the amount of salivary secretion at this age is much diminished.[8]

It has also been argued that there is a link between the use of SLS-containing toothpaste or mouthwash and an increased frequency of Recurrent Foot-and-Mouth Ulcers (RAU) in some patients.[31

3. Humectants

These are short chain polyalcohols that prevent the loss of water content and the subsequent hardening of the toothpaste in the tube or when it is exposed to air. They also provide the creamy texture of toothpaste.

Substances used as humectants are commonly used in the food and pharmaceutical industry, and should present a minimal health risk when used in toothpaste. However, Sorbitol can cause high-dose diarrhea, acting as an osmotic laxative. FAO / WHO recommends that sorbitol intake be limited to 150 mg / kg / day.[2]

4. Gelling agents / Binders

They are hydrophilic colloids that disperse or increase in volume in the presence of water. They are used to stabilize the toothpaste formula, preventing the separation of solid and liquid phases.[1]

a. The most widely used binding agent today is Sodium Carboxymethylcellulose (CMC). It is physiologically inactive, dissolves in water, is very compatible with other ingredients, very stable and has a relatively low cost.[1]

b. Sodium alginate consists mainly of the sodium salt of alginic acid, an odorless powder, or almost odorless and tasteless. It is slowly soluble in water, forming a viscous solution and insoluble in alcohol or ether. It is also used as a thickener in the preparation of water-miscible pastes, creams or gels.

c. Xanthan gum is a cream-colored, water-soluble powder (hot or cold) that forms solutions with a viscosity that remains unchanged by changes in temperature or pH. It is compatible with most salts, moderate surfactant concentrations and most preservatives. It tolerates alcohol concentrations of up to 50% and is non-toxic.[1]

5. Flavouring agents / Sweeteners

The flavouring agents cover the unpleasant taste of the other components of the toothpaste. They are solubilized and dispersed in paste, or liquid, with the help of surfactants. Combinations of water-insoluble essential oils, such as peppermint, mint, eucalyptus or menthol, or essential oils of anise, cloves, cumin, citrus, nutmeg, thyme or cinnamon are used.[3]

Soft tissue reactions may occur manifested as a direct irritant or as an allergic reaction to the mouth, lips or contact cheilitis. Rarely, allergic rhinitis or asthma may occur.

Like flavouring agents, sweeteners improve the taste of toothpaste. Sodium Saccharin, Sorbitol

and Glycerin are most commonly used.[1]

Xylitol is known to act as an agent to prevent carious lesions, and recent studies have shown that it is effective in reducing demineralization and accelerating enamel remineralization.[32]

6. **Preservatives**

They are essential ingredients widely added to cosmetics and personal care products for daily use, with the main purpose of preventing damage caused by microbial growth.

7. **Colouring agents**

The colouring agents added to the toothpaste give it an attractive look. Color substances are classified by the Color Index (CI), published by the Society of Dyers and Colorists and the American Association of Textile Chemists and Colorists, or by a system called FD&C Colors. The white color of toothpaste is given by Titanium Dioxide.[1]

Conclusions:

Two of the most prevalent diseases of the oral cavity, carious disease and periodontitis, are caused by biofilm. Effective removal of biofilm is an ongoing area of research, including that of new toothpaste formulations and effectivness. The success and longevity of oral healthcare is predicated on the one hand on regular professional maintenance and on the other, on individual home care.

Among ingredients advocated for use in toothpastes are compounds that fight and prevent the appearance of carious lesions, gingival diseases, halitosis, calculus, dental erosions, staining and dentinal hypersensitivity. Herbal toothpastes, which contain natural antibacterial agents, are a good alternative to reduce the risk of oral conditions in both children and adults.

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