Toothpaste composition

Dr. Rigó Orsolya
Toothpaste Technologies

A Short History of Toothpaste

500 BC  Toothpowders used by ancient Greeks

400 AD  Romans added astringents and other “therapeutics“ to the abrasives (crushed bones) - the start of "formulation,"

1892  Dr W Sheffield – “Cream Dentrifice” in collapsible tube

1900-1950s  Improvements in aesthetics were made including foaming, flavouring and sweetening and replacement of toothpowders with toothpastes

1955  P&G launched first mass market Fluoride toothpaste

1985  P&G launched the first mass market Tartar Control toothpaste

1990s  P&G, Colgate, Lever, SKB etc. launched anti-microbial, Triclosan-containing toothpastes
Statement of FDI (International Dental Association) and WHO

Main reasons for caries reduction in the industrialized western countries:

- Widespread use of **fluoride toothpaste**
- Preventive dental education
- Availability of regular dental visits

*toothpaste consumption at proper dental hygiene: 12 tubes/person/year in Hungary: ~ 2,4 tube/person/year*
Fluoride toothpaste is the most frequently used topical fluoride agent

Estimate of the numbers of people in the world using various types of fluoride therapy.

Modified from the World Health Organization, 1994
Current understanding of fluoride action:

predominant caries inhibitory effect of fluoride is the **topical, posteruptive effect**

- inhibition of demineralization
- enhancement of remineralization
- fluoride incorporation into the enamel

posteruptively important during the tooth development (little effect)

J.M. ten Cate, J.B. Featherstone: Fluoride in Dentistry, Munksgaard, 1996
Fluoride dentrifice should be used daily for tooth cleaning to control development and progression of dental caries lesion at all ages, but young children should be supervised.

- Enamel caries: 50% reduction
- Root caries: 67% reduction
Toothbrushing should begin:

7 Months = First Primary Teeth Erupt

Flossing...
can be initialized as needed
<table>
<thead>
<tr>
<th>Age</th>
<th>Fluoride conc (ppm)</th>
<th>Frequency of brushing daily</th>
<th>Amount of toothpaste</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 mont -2 year</td>
<td>low F toothpaste max 500 ppm</td>
<td>1x</td>
<td>small, film layer</td>
</tr>
<tr>
<td>2 – 6 year</td>
<td>max. 500</td>
<td>2 x</td>
<td>small pea size - or nail</td>
</tr>
<tr>
<td>Above 6 year</td>
<td>1000-1450</td>
<td>2 x</td>
<td>$\frac{1}{3} - \frac{1}{2}$ brush head</td>
</tr>
</tbody>
</table>

Use of fluoride toothpaste
Recommendations*

European Archives of PEDIATRIC DENTISTRY
Fluoride Symposium EAPD F guidelines
Volume 10 (Issue 3) Sept. 2009

<table>
<thead>
<tr>
<th>Age group</th>
<th>Fluoride concentration (ppm)</th>
<th>Daily use</th>
<th>Amount to be used</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 month-2years</td>
<td>500 ppm</td>
<td>twice</td>
<td>Pea- size</td>
</tr>
<tr>
<td>2 – 6 years</td>
<td>1000 (+) ppm</td>
<td>twice</td>
<td>Pea- size</td>
</tr>
<tr>
<td>6 years and over</td>
<td>1000-1450 ppm</td>
<td>twice</td>
<td>1-2 cm</td>
</tr>
</tbody>
</table>
Supervised Toothbrushing
Transformation of active - inactive lesion

effect of 3 month active oral hygiene
Toothpaste Technologies

Typical Toothpaste Composition

- Humectants: 34%
- Water: 34%
- Actives: 5%
- Binder: 1%
- Surfactant: 2%
- Buffers: 2%
- Flavour: 1%
- Colourants: 1%
- Abrasives: 20%
- Water: 34%
- Humectants: 34%
Toothpaste Technologies

Ingredients: Actives

- Anti-cavity e.g. Fluoride salts
- Tartar control e.g. Pyrophosphate
- Antimicrobial e.g. Triclosan, CPC, Zinc salts, Stannous salts

Acives 5%
Fluoride in Toothpaste – Mode of Action

Saliva

Free fluoride from dentifrice

promotes retention / formation

$\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$
Role of Fluoride

- **Enhance** the remineralization process
- **Decrease** enamel solubility
More free fluoride

Faster

More

Enamel Fluoride uptake

Smaller initial lesions

Less clinical caries

NaF

sodium (I) fluoride
Fluoride Rebuilds Enamel Every Time You Brush

Healthy tooth enamel before bacteria acid attack

Demineralized enamel - bacteria acid breaks tooth enamel down

Remineralized enamel - fluoride and minerals in saliva build tooth enamel up
Fluorides

Sodium fluoride

Sodium monofluorophosphate

Stannous fluoride

Amine fluoride

Nátriumfluorid

Nátrium monofluorofoszfát

Ónfluorid

Aminfluorid
## Fluoride Sources in Different Toothpastes

<table>
<thead>
<tr>
<th>Type of Fluoride</th>
<th>Toothpaste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Monofluorophosphate (SMFP) (Na₂FPO₃)</td>
<td>Aronal, several Colgate variants (Cavity Protection, Sensitive)</td>
</tr>
<tr>
<td>Stannous Fluoride (SnF₂)</td>
<td>blend-a-med EXPERT Gums Protection, Meridol,</td>
</tr>
<tr>
<td>Amine fluoride (AmF) (primarily in Europe)</td>
<td>Elmex orange, Meridol</td>
</tr>
<tr>
<td>Aluminium Fluoride (AlF₃)</td>
<td>Lacalut Active</td>
</tr>
<tr>
<td></td>
<td>NaF</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td><strong>Stops de-mineralization</strong></td>
<td>√</td>
</tr>
<tr>
<td><strong>Enhances re-mineralization</strong></td>
<td>√</td>
</tr>
<tr>
<td><strong>Mechanism</strong></td>
<td>creates F-apatite</td>
</tr>
<tr>
<td>Fluoride delivered directly or chemically changed to release F⁻</td>
<td>directly</td>
</tr>
<tr>
<td><strong>Anti-bacterial properties</strong></td>
<td>none</td>
</tr>
<tr>
<td><strong>Anti-hypersensitivity properties</strong></td>
<td>none</td>
</tr>
</tbody>
</table>
Sodium Fluoride (NaF) - Results

NaF results in better cavity protection than SMFP\(^2\)

Stabilized stannous fluoride/sodium hexametaphosphate helps achieve and maintain fresh breath

**Prevention of hydrogen sulphide production**

Mean hedonic score

- Baseline
- Week 1
- Week 3

49%* reduction in mean hedonic score from baseline to week 1
71%* reduction in mean hedonic score from baseline to week 3

* *p < 0.0001.

Stannous fluoride/sodium hexametaphosphate dentifrice resulted in sustained significant improvement in oral malodor relative to a control dentifrice.

Nachnani *J Dent Res* 2008 87 (Spec Issue B) Abstract 2864

* *p < 0.0001.

Nachnani *J. Dent. Res* 2008 87 (Spec Issue B) Abstract 2864
Common agents used for plaque and gingivitis in global toothpaste

- SF = Stannous Fluoride
- CHX = Chlorhexidine
- CPC = Cetylpyridinium chloride
- T = Triclosan

T = Triclosan
SF = Stannous Fluoride
CHX = Chlorhexidine
CPC = Cetylpyridinium chloride
Toothpaste Technologies

Ingredients: Abrasives

- Removes stain, increases “solidity”
- e.g. Silica, Alumina, Calcium Carbonate etc. (not baking soda)
Toothpaste Technologies

- **Silica — Mechanism of Action**

  - Particles of silica move with bristles of toothbrush
  
  - Particles *penetrate the protein layer* (pellicle) in which extrinsic stain is located
  
  - Brushing action drags the silica particles across the enamel and *remove the stained pellicle*

- Abrasivness/Cleaning Effects depends on silica level

- (grittyness)
Toothpaste Technologies

- **Enamel Safe Stain Removal**
  - Hand brush acrylic lenses with toothpaste for 2-4 minutes
  - When held up to light scratching may be seen if toothpaste is abrasive

Abrasive Whitening toothpaste (alumina)
Toothpaste Technologies

- **Active Ingredients**
- **Triclosan – Mechanism of Action**
  - Kills bacteria on the teeth (plaque) and on the tongue
  - Reduces bacterial metabolism and growth
  - Leads to improved plaque prevention and bad breath prevention
  - Plaque prevention leads to reduction in gum problems
Stabilized stannous fluoride/sodium metahexaphosphate delivers gum health benefits

Gum protection effect

1. Reduces gingival inflammation by 21% (*p<0.001)
2. Reduces gingival bleeding by 57% (*p<0.001)

Primary cause of bad breath is volatile sulfur compounds produced by bacteria.

Stannous fluoride reduces sulfides produced by bacteria and reduces malodor.
Toothpaste Technologies

- Active Ingredients
  - Pyrophosphate salts
  - Proven to help prevent formation of calculus (tartar) in Complete 7
  - Also helps in stain prevention / removal
  - Proven not to negatively affect caries prevention of fluoride
  - Proven to be systemically safe
Supra- and subgingival calculus
Figure 7

Orthophosphate

Pyrophosphate

Trimetaphosphate (cyclic)

Polypyrophosphate—here with 7 repeat units of orthophosphate (3.5 pyrophosphate units)
SHMP – Binding Mechanism

Pyrophosphate binds to calcium ions found in hydroxyapatite $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$.

$(\text{NaPO}_3)_{21}$
Pyrophosphate Salts – How Do They Work?

Healthy Clean Tooth

Calculus Formation

Pyrophosphates (P$_2$O$_7$)
SHMP – Stain Removal – elszíneződések eltávolítása

Baseline

Week 2

Baseline

Week 2

(\text{NaPO}_3)_{21}
SHMP – Mode of Action - Stain

- 10-12 times longer than pyrophosphate
- Greater surface affinity
- Strong attraction to calcium hydroxyapatite
- Disrupts pellicles to remove extrinsic stain
- Retained on tooth surface to prevent new extrinsic stain

\[(\text{NaPO}_3\text{)}_{21}\]

New stain

Old stain

Sodium hexametaphosphate

\[\text{Pellicle}\]

\[\text{Ca}^{2+} \quad \text{Ca}^{2+} \quad \text{Ca}^{2+} \quad \text{Ca}^{2+} \quad \text{Ca}^{2+} \quad \text{Ca}^{2}\]
Dental Hypersensitivity – What Is It?

• Healthy Teeth
  ➢ Dentin protected by gums and enamel

• Hypersensitive Teeth
  ➢ Recession of gums
  ➢ Loss of tooth enamel

Consequence

➢ Dentin (large number of pores leading to nerve) may become exposed

➢ Cold, heat, and sugar can irritate exposed dentin

PAIN, SENSITIVITY
Dental Hypersensitivity – How To Explain?

• Most widely accepted theory of how the pain occurs: **Brannstrom’s hydrodynamic theory** (fluid movement within the tubules)

• Pain evoking stimuli increase outward flow of fluid in tubules

• Causes pressure change across dentin

• Leading to activation of intradental nerves

• Stimulation = mechanoreceptor response that distorts the pulp nerves

Figure 2. Depiction of Brannstrom’s Theory.
Stannous Fluoride – Rapid Deposition for Dentinal Tubuli Blockage and Related Clinical Hypersensitivity Efficacy

\[
\begin{align*}
\text{SnF}_2(\text{aq}) & \rightarrow \text{OH}_{(\text{aq})} \\
H_2\text{O}_{(\text{aq})} & \\
\text{PO}_4(\text{aq}) + \text{F}_{(\text{aq})} & \rightarrow \text{SnOH}_2\text{Sn}_{x}\text{O}_y\text{OH}_z(\text{s}) \\
\text{O}_2(\text{aq}) & \\
\text{Sn}_3(\text{PO}_4)_2(\text{s}) & \\
\text{Sn}_3\text{PO}_4\text{F}_3(\text{s}) & \\
\text{SnO}_2(\text{s}) & \\
\end{align*}
\]

Solution Ions in Dentinal Fluid and Saliva

Insoluble Sn Reaction Products
Treatment of hypersensitivity

- SnF$_2$ leads to partial or complete occlusion of the tubules. Blocked tubules—stimulation of mechanoreceptors does not occur.

- Prevention of pain response.

Anti Hypersensitivity Ingredients

Possible desensitizing agents in toothpastes:

- Potassium Nitrate
- Stannous Fluoride
- Potassium Chloride
- Strontium Chloride Hexahydrate
- and Aluminium, Potassium or Ferric Oxalates
KNO₃ – ADA Seal of Acceptance

The ADA Council on Scientific Affairs has granted a Seal of Acceptance to dentifrices containing 5% potassium nitrate (1)

(The ADA conducts extensive laboratory tests on toothpastes to determine whether they meet specific criteria for safety and effectiveness. They also review all clinical data in support of key product claims. The Seal provides consumer assurance that the toothpaste has met the ADA criteria for safety and effectiveness. Consumers can trust that claims made on packaging and labelling for ADA-Accepted products are true, because companies must verify all of the information to the ADA.9

A Cochrane review published in 2004:

- No clear evidence is available for the support of potassium containing toothpastes for dentine hypersensitivity."

- Nincs eléggé megfelelő tudományos bizonyítékek a káliumnitrát dentinérzékenység elleni hatásának igazolására”

---

Toothpaste Technologies

Ingredients: **Surfactants**

- Foaming, emulsifies oily ingredients, cleaning and anti-microbial
  - e.g. **Sodium Lauryl Sulfate**, Poloxamer
Toothpaste Technologies

Ingredients: Water

- Gives flowability
- Dissolves actives and thickeners
Toothpaste Technologies

Ingredients: **Humectants**

- Gives flowability, prevents dry-out and prevents microbial growth
- e.g. Sorbitol, Glycerin
Toothpaste Technologies

Ingredients: Buffers

- Maintain chemical and physical stability
- e.g. Phosphate salts, Citrate salts, Carbonate salts, (Bicarbonate salts)
Toothpaste Technologies

Ingredients: Thickeners

- Provide structure and thickening
- e.g. Xanthan gum, Cellulose gum, Carbomer etc. etc.
Toothpaste Technologies

Ingredients: Flavours and Sweeteners

- Flavours e.g. Peppermint, Menthol, Spearmint
- High intensity sweeteners e.g. Saccharin, Xylitol
Toothpaste Technologies

Ingredients: Visual Effects

- Colours e.g. dyes and pigments
- Opacifiers e.g. titanium dioxide
- Special visual effects e.g. pigmented silica, mica
HEALTH SANDWICH
$3.95

WE JUST ADD A LITTLE TOOTHPASTE!