Nano-Silver Fluoride Toothpaste

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Toothpaste with NSF (Nano-Silver Fluoride) seems to have significant antiadherence and antiacidogenicity when compared to toothpaste that has fluoride alone. Similarly, to NaF, NSF also prevents mineral loss on the enamel and has the advantage of not staining the teeth black like with silver diamine fluoride. Ultimately, I believe that a better oral hygiene regimen may actually triumph the use of NaF vs NSF, but for patients who are not able to have good oral hygiene due to various reseaons, toothpaste containing NSF can have potential benefits.

New Nano-Silver Fluoride-Containing Dentifrice

Mutans streptococci:
- Most cariogenic

bacteria Fluoride:
- Prevents caries in children and adolescents
- Inhibits demineralization of enamel by forming acid-resistant mineral fluorapatite
- Inhibits bacterial activity and acid production of S.

mutans. Silver:
- Antibacterial activity on a wide range of microorganisms
- At low concentrations, is not toxic to human cells.
- High chemical affinity for compounds containing nitrogen, sulfur, and phosphorus
    - Possible interaction with the thiol groups of proteins and the phospholipid portion of the bacterial membrane.
    - In nanoparticles, more intense interaction with other organic and inorganic molecules (greater surface area), thus altering bacterial cell wall permeability
    - Prevent cell replication process by interactin with nucleic acids

In vitro studies have successfully tested the bactericidal action of silver nanoparticles (AgNPs) on S. mutans.

Bactericidal properties depended on the size of the particles:
- Smaller diameter = lower inhibitory concentrations
- AgNPs at a concentration of 4.86 ± 2.71 g/mL are sufficient to inhibit the growth of S. mutans even when organized as biofilm, suggesting that they can be used for the prevention and treatment of caries.

Nano-silver fluoride (NSF):
- Developed in order to be a new anticarie agent.
- Colloid based on chitosan, silver nanoparticles, and fluoride
- No substantial risk for use in living organisms or harm to human health,
- Caries arresting property described in a controlled clinical trial.

- No distinctive tissue darkening of silver ion oxidation when in contact with the teeth (unlike silver diamine fluoride).

Mechanism of arrestment is not clear and preventive action on sound enamel has not yet been reported.

In this study, NSF was synthesized and formulated into a dentifrice and following effects were evaluated:

- Reduction in the production of acid and adhesion of S. mutans AU 159
- Reduction in mineral loss during pH decline by microhardness analysis and optical coherence tomography (OCT).

Materials and methods:

Use of a standard strain S. mutans

AU159 Preparation of NSF

Preparation of Dentifrices

- Test group: NSF containing dentifrice
- Control group: NSF-free dentifrices

Determination of Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC).

Adherence Test

Enamel samples: from caries-free deciduous molars extracted for natural exfoliation. Saliva: from volunteers aged 20 to 30 years old who were not taking any systemic medications.

20 enamel fragments immersed dentifrice slurry, according to their group, for 1 minute. The enamel fragments removed washed with sterile deionized water placed into the test tubes containing the bacterial suspension and PBS-treated saliva after 2 hours, transferred to sterile saline (0.9% sodium chloride) sonicated (to release the bacteria adhered to the enamel).

The quantification of the microorganisms that adhered to dental enamel was determined by:

- Direct reading of CFU
- Subsequent calculations of the adsorption inhibition percentage for each test solution.

Acidogenicity

pH determined in bacterial growth media

Evaluation of NSF Dentifrice Performance in Enamel Remineralization

Samples = 48 deciduous teeth free of caries.
Teeth cleaned, autoclaved, and stored in distilled water under refrigeration. The specimens were randomly divided into three groups:

- Test group (NSF dentifrice),
- Positive control group (NaF dentifrice),
- Negative control group (deionized water).

Microhardness determined as the baseline as well a final microhardness.

Statistics and OCT Images Analysis

All data were converted to percentages and were then analyzed by SPSS 13.0.

- Inhibition percentage of bacterial adsorption
- Percentage of pH variation
- Percentage of microhardness variation

Data evaluated for the normality and

homogeneity.

The OCT results were processed with ImageJ software (comparing the integrity of the enamel surface and the volume loss for the tissue, after pH cycling, with the initial image).

Results

MIC and MBC

MIC of the test dentifrice (NSF) for S. mutans AU159 was 30 ppm.

MIC of the control dentifrice (NaF) was 180 ppm for the same bacterium.

In relation to the MBC, neither the test nor the control dentifrices showed bactericidal action on S. mutans AU159.

Adherence Test

NSF-containing dentifrices better at preventing bacterial adhesion to tooth surface that NaF- containing dentifrices

Acidogenicity

NSF dentifrices prevent the pH decrease
Control dentifrices pH decreases after 24 hours of the bacterial incubation.

Enamel Surface Microhardness

no statistically significant difference between the NSF dentifrice and the NaF dentifrice, (both have same ability to avoid demineralization).
Significant differences between the negative control solution compared to the NSF and NaF dentifrices.

OCT Images

The OCT analysis was performed at T_i and at T_f.
NaF and NSF show similar behaviors, while the negative control group has a lower extinction coefficient.

Discussion

The novelty of this study: enhance dentifrices with NSF in order to reduce the bacterial growth. NSF in dentifrices may be an alternative approach to prevent caries.

Compared to 1,200 ppm NaF dentifrice, NSF might significantly improve antibacterial efficacy.

The MIC of the NSF dentifrice is 1/6th of that of the NaF dentifrice, suggesting synergistic antibacterial action between the AgNPs, chitosan, and fluoride components in the NSF (Further studies needed).

NSF demonstrated bacteriostatic but not bactericidal actions ecologically good since successful antimicrobial agents avoid the disruption of the natural and beneficial resident oral bacteria.

Silver ions have shown the ability to prevent bacterial biofilm formation by disrupting cell-cell and cell-surface adhesion.

Antiadherence properties of AgNPs associated with the smaller particle size and can be related to the significantly superior performance of the test dentifrices.

NaF dentifrices has almost half of the beneficial action of the dentifrices containing NSF in preventing bacterial adhesion.

Fluorides are effective for acidogenicity reduction on cariogenic biofilms even at low concentrations of 10 ppm of NaF. However, in this study, this was not observed. (i.e. samples with NaF-containing dentifrice showed a decrease in pH at the end of the

experiment.

Results showed inhibitory effects of the NSF-containing dentifrice treatment on S. mutans alone, not on multispecies (limitation of study).

Similar effect (nonstatistically significant difference) of both NSF and NaF dentifrices on enamel demineralization even though NaF had lower percentage of microhardness variation.

NSF dentifrice-treated samples did not show black stains like SDF (reduction to nanometer in silver particles chemical reactivity altered AgNPs colloid was not able to stain the teeth black.

These results are a satisfactory outcome because NaF is considered the reference standard for the prevention of enamel demineralization.

The OCT images, validate the data found in the microhardness test of this study: NSF has ability to prevent demineralization of primary tooth enamel.

- Important outcome because deciduous enamel is more susceptible to demineralization (it is more porous and permeable than permanent tooth)
- Increased permeability of the deciduous enamel favors the action of fluorides, (diffuses about 150x more than permanent teeth).

NSF dentifrice could potentially be used for self-care caries control and in public health programs.

Reference:

Teixeira, J. et al (2018). Effects of a New Nano-Silver Fluoride-Containing Dentifrice on Demineralization of Enamel and Streptococcus mutans Adhesion and Acidogenicity. *International Journal of Dentistry*, 2018, pp.1-9. (https://www.hindawi.com/journals/ijd/2018/1351925/)