Effect of Xylitol on Enamel Fluoride Uptake and Remineralization

R.V. Faller*, S.L. Eversole, A.M. Pfarrer
Procter & Gamble Co., Mason, OH, USA

ABSTRACT

Xylitol, a non-nutritive sweetener, has been suggested as being anti-cariogenic as well as non-cariogenic. One of the proposed anticariogenic mechanisms of action is through an enhancement of remineralization. The purpose of this *in vitro* pH cycling study was to determine the effect of xylitol on fluoride (F) uptake and remineralization using F toothpastes as a control. Test products included: (A) 1450ppm F (NaF); (B) 1450ppm F (NaF) + 10% xylitol; (C) 2800ppm F (NaF); (D) 1500ppm F (SMFP); (E) Placebo (0 ppm F). Products A,B,C,E were formulated using the same fluoride compatible silica abrasive. Product D was a marketed product, also formulated with silica. 4mm diameter enamel discs were cut from human incisors that were free of major surface cracks or other visual imperfections (10X). Lesions were prepared according to the method of White, *Caries Res*, 1989. After demineralization, 1/3 of each specimen was covered with acid resistant varnish to serve as an untreated control area. Treatment consisted of exposing specimens to a mixture of 1 part toothpaste:3 parts saliva for 1 minute, 4x/day/6 days. Between the 2d and 3d treatments each day was a 3hr demineralization period. After 6 treatment days, F uptake (microdrill biopsy) was measured. An additional 1/3 of each specimen was then covered with nail varnish and specimens exposed for 72hrs to demineralization solution. Following secondary demineralization, specimens were cross-sectioned, radiographed and analyzed using quantitative microradiography. Control, remineralized and acid challenged areas of each specimen were measured. Fluoride uptake ($\mu g/cm^2$) for each product: (A) 35.5; (B) 36.9; (C) 63.9; (D) 8.0; (E) 3.1. Remineralization (Delta Z): (A) -536; (B) -580; (C) -822; (D) -113; (E) +107. Acid resistance (Delta Z): (A) -211; (B) -236; (C) -515; (D) -22; (E) +693. For each parameter assessed, statistical breakouts were identical, with C>A=B>D>E (p=0.05). **The data indicate 10% Xylitol has no effect on fluoride uptake compared to a conventional NaF toothpaste. Further, the data confirm xylitol does not enhance remineralization of demineralized enamel, nor does it enhance the acid resistance of remineralized enamel.**

INTRODUCTION

Many non-nutritive sweeteners are accepted as being non-cariogenic. These sweeteners, primarily sugar alcohols, include mannitol, sorbitol, maltitol, xylitol, etc. There have been suggestions in the literature that some of the sugar alcohols, such as maltitol and xylitol, may be anticariogenic. A recent caries clinical study (Sintes et. al., 1995) demonstrated a significant benefit (additional 12% reduction in DMFS) for a group of children receiving an 1100ppm F (NaF) dentifrice containing 10% xylitol compared to a group receiving a conventional 1100ppm F (NaF) dentifrice. Most researchers believe the primary mechanism of action of xylitol is through its inhibition of the glycolytic pathway. Although the bacteria ingest xylitol, they are unable to digest/metabolize it. The generation of lactic acid is reduced relative to a non-xylitol environment. Less acid production results in less challenge to the teeth, which is manifest as a net reduction in demineralization. A few researchers have suggested that xylitol may exhibit anticaries effects through enhancement of the remineralization process, a function previously attributed mainly to fluoride. This proposed mechanism can be studied using *in vitro* models that are not susceptible to bacterial effects. The model utilized in this study is one such model. In addition, this model provides fluoride (F) uptake data, which is important for demonstrating whether or not additives such as xylitol interfere with fluoride incorporation into demineralized enamel. F uptake is often considered a key parameter in assessing anticaries efficacy of fluoride-based formulations.

MATERIALS AND METHODS

Subsurface human enamel specimens were placed in 25 ml of a solution containing 0.5M lactic acid, 0.2% Carbopol 907 (B.F. Goodrich Co.), 50% saturated with respect to HAP, pH 5.0 for 96 hours at 37°C. Specimens were placed in groups (n=4) in such a way that the average surface hardness of each group of specimens was not significantly different (Leitz miniload @ 200g). Each group of specimens was placed in 20 ml of fresh, pooled human saliva for 1 hour to form an initial layer of pellicle on the demineralized enamel surfaces. Treatments consisted of 1:3 (w/w) mixtures of dentifrice:saliva, with a fresh slurry prepared for each treatment.

Treatments were made 4 times per day for 6 days. Upon completion of pH cycling, specimens were analyzed for fluoride content using the microdrill biopsy technique. Results are reported in µg of F per square centimeter of surface sampled. Microradiographic analyses (remineralization, acid resistance) were conducted using standard techniques. Results are reported as Delta values (Vol. % mineral x microns).

OBJECTIVE

The objective of this study was to determine the effect of the addition of xylitol to a conventional NaF toothpaste. Parameters assessed included fluoride uptake, remineralization and acquired acid resistance, measured using an *in vitro* pH cycling model that correlates well with *in situ* model studies.

RESULTS

TREATMENT	F Uptake ($\mu g/cm^2$)	Remin (Delta $Z_{rem - i}$)	Acid Resist. (Delta $Z_{ac - i}$)
2800ppm F (NaF)	63.9 (a)	-822 (a)	-515 (a)
1450ppm F (NaF)	36.9 (b)	-580 (b)	-236 (b)
+ 10% Xylitol			
1450ppm F (NaF)	35.5 (b)	-536 (b)	-211 (b)
1500ppm F (SMFP)	8.0 (c)	-113 (c)	- 22 (c)
Placebo (0 ppm F)	3.1 (d)	+107 (d)	+693 (d)

(all statistical breakouts ( ) were calculated at p = 0.05, ANOVA by the LSD test).

Research presented at the ADA/FDI World Dental Congress, Orlando, September 28 - October 1, 1996

P&G

Effect of Xylitol on Enamel Fluoride Uptake and Remineralization
R.V. Faller*, S.L. Eversole, A.M. Pfarrer
Procter & Gamble Co., Mason, OH, USA
Pg. 2

DISCUSSION

This study confirms the ability of the model system to statistically separate differences in both F uptake and remineralization over a wide range of F dose (0 - 2800ppm F). Consistent with clinical dose response studies, the 2800ppm F (NaF) product performed in a manner that was statistically superior to the NaF controls. In addition, all NaF based formulations performed significantly better than the SMFP control, which is in agreement with the preponderance of published data comparing NaF and SMFP dentifrice systems. The model system used here responds primarily to conditions relating to enamel hard tissue rather than to microbial effects. As the model demonstrates a high level of sensitivity to both fluoridation and remineralization effects, it is expected that the model would also show any enhancement of these parameters as a function of a toothpaste additive; assuming the additive possessed such qualities.

This study provides no statistical evidence that the addition of xylitol to a sodium fluoride dentifrice results in any enhanced efficacy that will be manifest as an enhancement in fluoride uptake, remineralization or acquired acid resistance of the treated enamel. At the same time, the data suggest the addition of xylitol to a sodium fluoride toothpaste does not interfere with the fluoridation, remineralization or inhibition of demineralization qualities attributable to a conventional sodium fluoride toothpaste.

Rather than through its impact on enamel fluoridation or remineralization, it appears likely that the primary mechanism of action of xylitol based products is through interactions affecting bacterial metabolism. The most likely scenario is that in reducing the amount of acid produced by bacteria, the level of cariogenic challenge is lessened.

CONCLUSION

-A dentifrice containing 2800ppm F (NaF) performed superior, in all parameters measured, to all of the other products included in this study.

-The addition of xylitol, a non-nutritive sweetener, to a sodium fluoride toothpaste did not inhibit the anticaries activity of the sodium fluoride.

-The addition of xylitol, a non-nutritive sweetener, to a sodium fluoride toothpaste failed to demonstrate any enhancement in fluoride uptake, remineralization or acid resistance from the combination of NaF + xylitol compared to NaF alone.

These data suggest any additional anticaries benefit resulting from the combination of xylitol and NaF is likely the result of a mechanism other than fluoride enhancement or one that directly effects the remineralization process.

Research presented at the ADA/FDI World Dental Congress, Orlando, September 28 - October 1, 1996

P&G