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Research Findings on Xylitol and the Development of Xylitol Vehicles to Address Public Health Needs

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Abstract

Xylitol has been demonstrated to be a safe and effective tooth decay preventive agent when used habitually. Nevertheless, its application has been limited by absence of formulations that demand minimal adherence and are acceptable and safe in settings where chewing gum may not be allowed. A substantial literature suggests that a minimum of five to six grams and three exposures per day from chewing gum or candies are needed for a clinical effect. At the same time there is conflicting evidence in the literature from toothpaste studies suggesting that lower-doses and less frequent exposures might be effective. The growing use of xylitol as a sweetener in low amounts in foods and other consumables is, simultaneously, increasing the overall exposure of the public to xylitol and may have additive benefits.

In this paper the authors address the questions: (1) What is the minimum dose and frequency for use of xylitol containing chewing gum for significantly lowering mutans streptococci levels? And (2) can delivery vehicles be produced that are applicable in settings where chewing gum or similar confections might be permitted?

Chewing Gum

A randomized controlled trial was carried out to determine the dose-response effects of *S. mutans* in plaque and unstimulated saliva to xylitol gum (Milgrom et al., 2006). Participants (N=132) were randomized into four groups: controls of 9.83 g sorbitol/0.702 g maltitol/day (G1), 3.44 g xylitol/day (G2), 6.88 g xylitol/day (G3), and 10.32 g xylitol/day (G4) in the form of 12 pellets (3 pellets/4 times/day). Plaque was collected in a standardized manner from specific sites but was not weighed. Baseline, 5-week, and 6-month samples of plaque and unstimulated saliva showed decreasing levels of *S. mutans* across treatment groups of increasing dose. Xylitol at 6.88 g/day and 10.32 g/day reduced *S. mutans* in plaque at 5 weeks, and in plaque and saliva at 6 months (Figure 1). Results suggested a plateau effect for both plaque and saliva, indicating that exceeding the daily dose of xylitol 10.32 g/day is not likely to increase effectiveness. Alternatively, a dose of 3.44 g/day is not likely to show reductions in *S. mutans* levels.

A five week randomized controlled trial was conducted in order to determine the reduction in *S. mutans* levels in plaque and unstimulated saliva to increasing frequency of xylitol gum use at a fixed daily dose of 10.32 g (Ly et al., 2006.) Participants (N=132) received either 10.32 g xylitol/day in the active group or 9.83 g sorbitol/0.7 g maltitol/day in the control group. The 10.32 g dose was used because it clearly would allow testing of the hypothesis

even though a smaller dose (e.g. 6.88 g) might also have been possible. The number of pieces of gum did not change, and frequency of chewing (times per day) varied from 2 to 4 times/day within the active group; the control group chewed gum 4 times/day. There were no significant differences in *S. mutans* level among the groups at baseline. At five weeks, there was a linear reduction in *S. mutans* in plaque and unstimulated saliva to increasing frequency of xylitol gum use at a constant daily dose of 10.32 g (Figure 2). Although the difference observed for the xylitol two times/day group was consistent with the model, the difference was not statistically significant.

Alternative Vehicles

Study one of a recent experiment compared the potential of pediatric topical syrup to deliver xylitol versus chewing gum. The basic rationale was that if the salivary xylitol concentrations were similar to chewing gum over a similar period, the effect on the oral flora should be the same and a xylitol delivery system for the very young is desirable. Others also have considered syrup or child's dummy (pacifier) as a delivery vehicle (Uhari, 1996, 1998; Taipale et al., 2006)

A within-subjects study design was employed to compare the presence and time course of xylitol concentrations in saliva from different delivery methods. Xylitol-containing pellet chewing gum (2.6 g) and 33% xylitol syrup (2.67 g) are presented here (Riedy et al., 2008). Adult subjects (N=15) consumed one product per visit with a 7-day washout period between products. Saliva samples were collected according to a standardized protocol at baseline and at ten regular intervals following exposure. HPLC was used to quantify xylitol concentrations. Mean salivary xylitol concentrations and bimodal time curves were similar for the two delivery methods (Figure 3); the correlation coefficient (r^2) between the mean xylitol concentrations at each time point for xylitol pellet chewing gum and the syrup was 0.96. Total AUC for the two products did not differ significantly (pellet gum – 63.0 ng.min/mL, syrup – 59.0 ng.min/mL).

A randomized control trial of xylitol syrup on early childhood caries has been conducted (Milgrom et al., 2008 (under peer-review)). Children at 9 to 15 months of age were randomized to three conditions in which all were given syrup orally three times per day by their mother/caretaker. The groups were: 3 doses of 2.67 g xylitol each (8 g/day); 2 doses of 4.0 g xylitol per day plus a single dose of a sorbitol placebo (8 g/day xylitol); or a single dose of 2.67 g xylitol plus two sorbitol placebo doses. Results show the pediatric topical syrup was highly effective in preventing early childhood caries in a population with very high rates of disease by 24 months of age.

In the second study of the xylitol salivary level experiment above (Riedy et al., 2008), bear shaped xylitol confections (2.6 g) were compared to xylitol pellet gum (2.6 g) at similar concentration. Another set of subjects (N=15) served as their own control. The study method and saliva sampling were as described for study one, the pellet gum compared to syrup study above. Mean salivary xylitol concentrations and bimodal time curves were similar for the two delivery methods; the correlation coefficient (r^2) between the mean xylitol concentrations at each time point for xylitol pellet chewing gum and the gummy bears was 0.99. Total AUC for the two products did not differ significantly (pellet gum – 63.0 ng.min/mL, gummy bears – 55.9 ng.min/mL).

A randomized trial of the same bear shaped confection is now being conducted in which the target is prevention of tooth decay in first permanent molars. About 30 percent of first molars are decayed by first grade. This current study is designed to address the targeted use of xylitol when the first permanent molars are erupting (Hujoel et al., 1999). The study is a two group, 30-month randomized controlled clinical trial designed to assess the use of

xylitol gummy bears as snack food during school hours to reduce dental caries among kindergarten children. Nearly all the children have untreated tooth decay in their primary teeth. Three hundred children are being randomized over two years into one of two treatment groups, receiving either six xylitol (1.3 g/piece, 2.6 g/dose—7.8 g/day) or six placebo gummy bears, distributed in the classroom evenly three times a day, for nine months.

Discussion

The work presented confirms the interpretation of data from clinical studies regarding frequency and dose (Isokangas, 1987; Rekola, 1989; Mäkinen et al., 1995). One caution is that the effectiveness of the lowest dose in the Milgrom and colleagues study (2006) may have been masked because the subjects had background levels of xylitol exposure, apparently from the diet. The bacterial reductions are a surrogate for reductions in tooth decay but this is permissible because the mechanism of action of xylitol is specifically antibacterial and a number of studies have demonstrated parallel reductions of *S. mutans* and tooth decay. Thus, the correspondence between the findings in the Milgrom series and the clinical studies already in the literature means that chewing gum can be used as a vehicle in institutional programs. However, there will still be adherence issues related to those who must administer or supervise use. Gum has been shown to be less effective in individual treatment programs because of lack of adherence (Isotupa et al., 1995; Stecksén-Blicks, 2004).

A controlled study of complex design of xylitol containing candies and gum was conducted in children about 10 years old (Alanen et al., 2000). This age group was targeted because of the potential to protect erupting second permanent molars. Three xylitol test groups received either candies (xylitol-maltitol or xylitol-polydextrose) or gum at 5 grams per day divided into three doses over several years depending on the group. The results showed 35 to 60 percent reductions in caries incidence in the test groups relative to the controls and no difference between xylitol delivery vehicles. This study is important both because of its result in the same dosage/frequency range as the previous studies and because the trial was intentionally sized to have adequate statistical power even with anticipated attrition.

In contrast there have been at least two studies attempting to demonstrate an effect of lower dosages. A non-randomized trial (Honkala et al., 2006) compared one xylitol candy three times per day (assumed to be 1.9 g total/day; the paper is unclear as to dose) to an untreated control in children and young adults in a school for the disabled. The control group consisted of students whose parents did not consent to the study. Baseline caries scores were fairly high and similar yet the test group showed a significant reduction in caries incidence relative to the untreated controls. This may indeed have been because the test candy, according to the manufacturer's website, was actually a 1:1 mixture of xylitol and maltitol. Other studies have shown that confections sweetened with maltitol alone reduced *S. mutans* levels in daily use with children (Ly et al., 2008). Thus, it is likely inaccurate to assert that 1.9 g xylitol per day alone is effective.

Oscarson and colleagues (2006) attempted to prevent caries in preschool children using 0.5 to 1.0 grams of xylitol in lozenges beginning around age 2. This study failed to show any effect largely because the underlying caries rate was extremely low (less than 1 dmfs per child at 4 years old) and the study had not been designed to detect such small, perhaps clinically insignificant, differences in the first place. Neither of these publications gives any rationale for the low dosages.

Xylitol-containing dentifrice

Several studies have evaluated sodium fluoride toothpaste formulations with xylitol. In all they raise questions, in view of the previous data presented, as to how an exposure of as little as 0.1 to 0.2 g per day xylitol (assuming a 1 g dose of toothpaste that is 10% xylitol and given no more than twice per day) could result in significant reductions of *S. mutans* and dental caries. Unpublished work by Söderling and colleagues has shown that low-dose xylitol decreases the growth of specific mutans strains in culture during the growth phase but this is hardly the same situation as in the mouth. Early short-term study of a xylitol-glycerol dentifrice showed reductions in salivary mutans (Svanberg & Birkhed, 1991).

In a study of 155 university students with high *S. mutans* levels comparing three fluoridated dentifrices (toothpaste with or without triclosan, or triclosan plus 10% xylitol), only the toothpaste with triclosan and xylitol showed significant reductions in plaque and saliva mutans levels from the placebo at 6 months although the levels dropped in all the groups (Jannesson et al. 2002). In this study the students were instructed to use about 1.5 cm of the dentifrice (about 1 g) and to refrain from rinsing. The authors argue that the proprietary toothpaste was formulated to optimize the bioavailability of the xylitol and that the dose used was larger than in other studies (for example, see Twetman & Peterson, 1995). No data were presented on how long the xylitol was present in the mouth after the exposures nor were there data on adherence. It is possible that the effects of triclosan and xylitol are synergistic. The time-response effect seen in this study is consistent with the Milgrom and colleagues studies of xylitol-containing chewing gum.

A prospective study of 2,630 Costa Rican children, initially eight to 10 years of age, brushing twice daily with fluoride toothpaste with 10% xylitol or fluoride toothpaste alone reported a 12% reduction in decayed/filled surfaces (DFS) and 11% reduction in decayed/filled buccal and lingual surfaces (DFS-BL) among those children brushing with fluoride toothpaste and xylitol after three years (Sintes et al., 1995). This study should to be interpreted cautiously as there was nearly 40 percent attrition in the subject population and the analysis did not employ intent-to-treat analytical methods. Another 30-month study by the same investigators of 3,394 seven to 12 year old children who used either fluoride toothpaste with and without 10% xylitol showed DFS and DFT increments of 1.30 and 0.69, respectively, for the 10% xylitol group when compared with the fluoride toothpaste only group (Sintes et al., 2002). Again, there were limitations in the study design and synergy between fluoride and xylitol cannot be ruled out. An additional concern is that these toothpastes contained sodium lauryl sulfate as a detergent, which may decrease the effectiveness of the xylitol (Assev et al., 1997).

Low-Dose Non-Intentional Exposure to Xylitol

In the U.S., for example, xylitol is being added in small non-clinical amounts as a sweetener or advertising gimmick to various foods and children's vitamins. Tables 1 and 2 give examples of many of the products containing xylitol in the US. It is possible that frequent lower dose exposure to xylitol is beneficial without the effort to maintain special programs. It is not possible to answer this question from the existing literature; however, two-thirds of the subjects in the Milgrom and colleagues study (2006) had been exposed to low levels of xylitol in their diets (Roberts et al., 2002).

Conclusions

In spite of the considerable evidence that xylitol is an effective caries preventive and cariostatic agent; an effective delivery system for xylitol, especially for children, demanding minimal adherence yet safe has not been developed. A substantial body of work suggests that a minimum of five to six grams and three exposures per day are needed for a clinical

effect. At the same time there is conflicting evidence in the literature from the xylitol toothpaste studies suggesting that lower-doses and less frequent exposures might be effective but the synergistic effects of xylitol and fluoride or triclosan cannot be ruled out. Studies of new vehicles for xylitol such as a xylitol releasing dummy and a pediatric syrup have been conducted.

Acknowledgments

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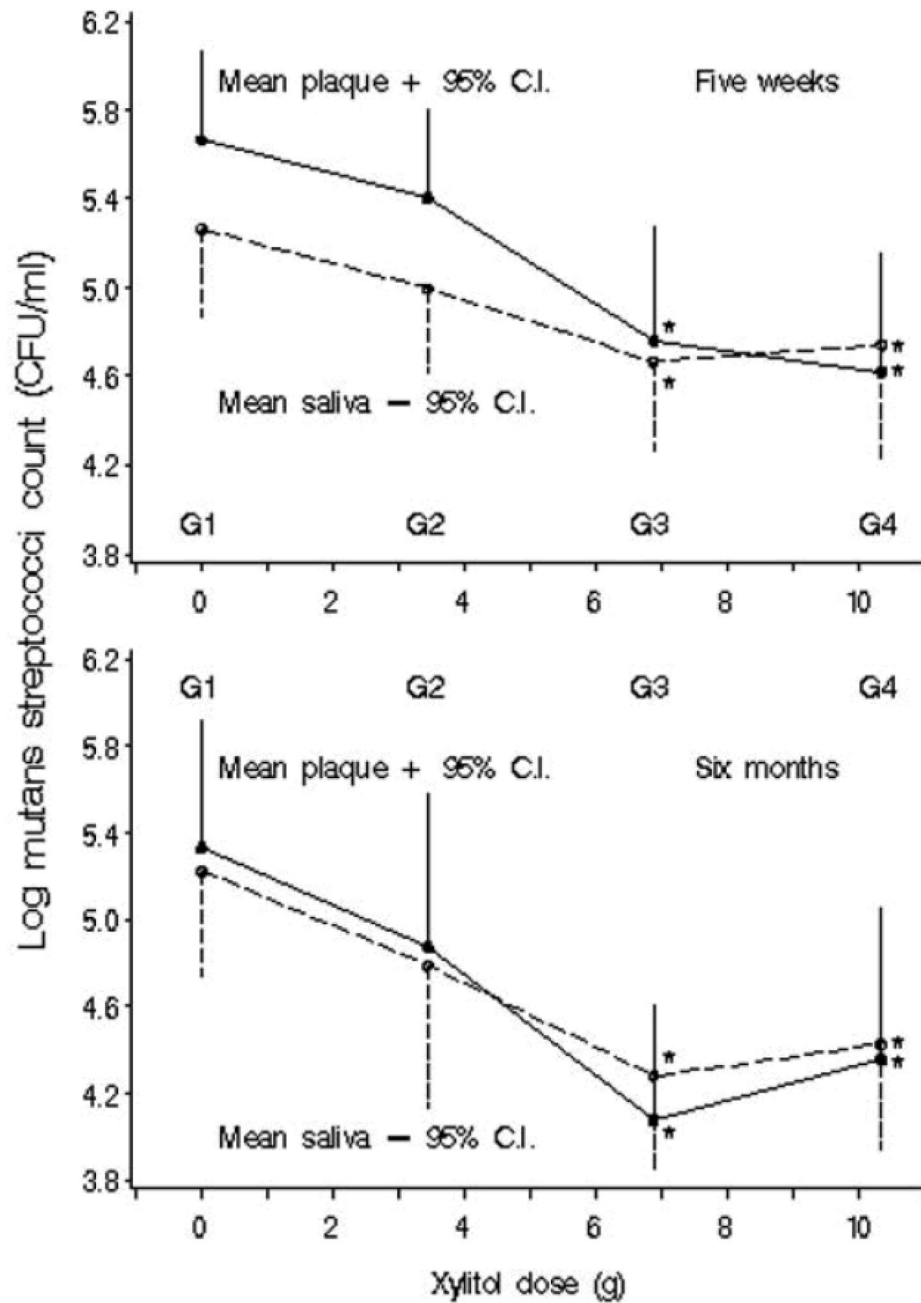


Figure 1. Mean log₁₀ CFU mutans streptococci/mL in plaque and unstimulated saliva by xylitol dose at 5 wks and at 6 mos (N=33 in each group). *Significant-difference group compared with placebo (G1) in least-significant-difference multiple comparisons. (Reprinted from Milgrom P, et al. 2006 with permission)

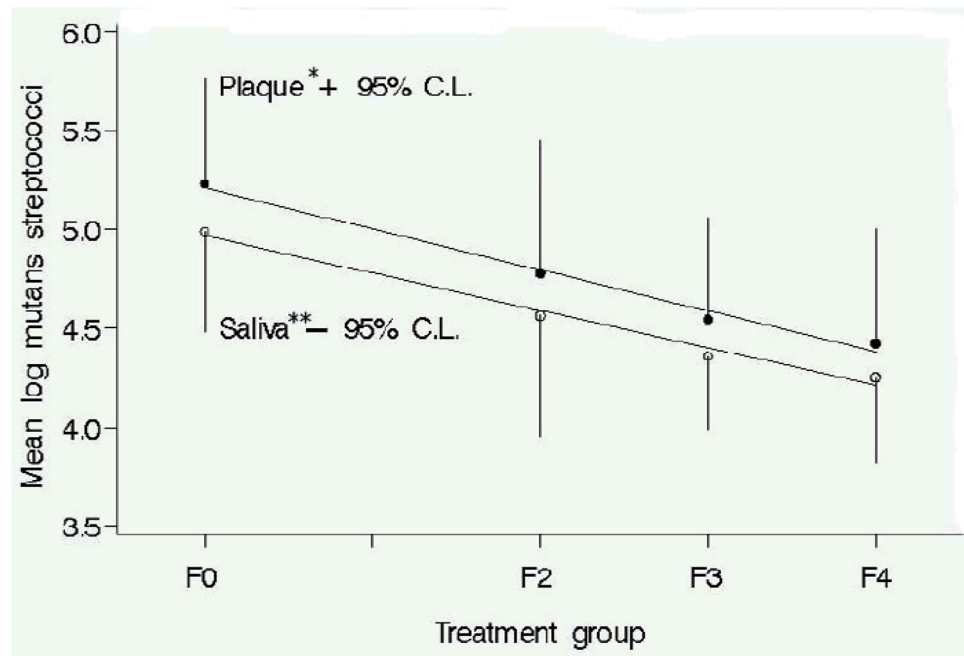


Figure 2.

Mutans streptococci counts in plaque and unstimulated saliva at five weeks and best fit linear line. Linear reduction of mutans streptococci levels of xylitol chewing gum use at constant daily dose (10.32 g/day). Linear line equations: plaque -*log mutans streptococci = $-.21(\text{Frequency})+5.21$; unstimulated saliva-**log mutans streptococci = $-.19(\text{frequency})+5.07$. Group F0 = Sorbitol Control; F2 = xylitol 2x/d; F3 = xylitol 3x/d; F4 = xylitol 4x/d. N=33 subjects per group. (reprinted from Ly KA, et al., 2006)

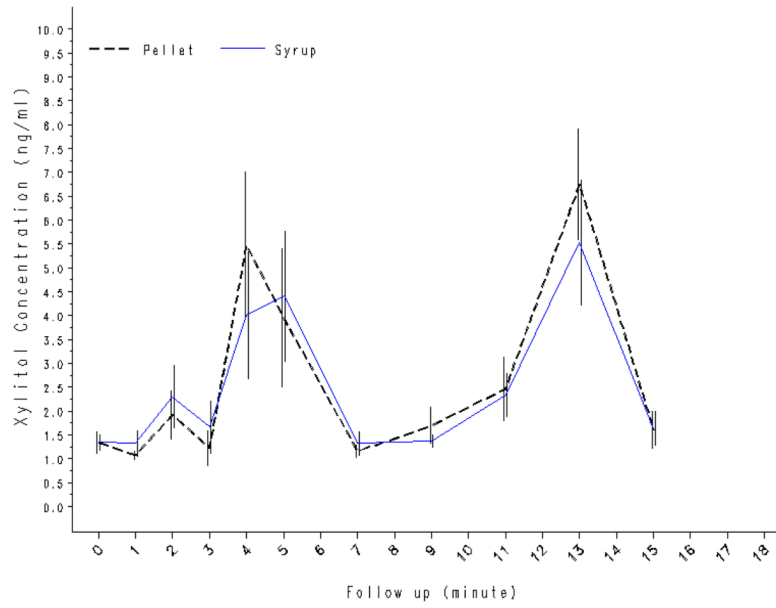


Figure 3. Comparison of salivary xylitol concentrations (ng/mL) after using xylitol-containing gum and syrup (N=15). (Adapted from Riedy CA et al., 2008)

Table 1
Xylitol Containing Gums and Mints Available in U.S. Markets, Their Xylitol Content, Preventive Potential, and Availability

PRODUCTS [†]	XYLITOL grams (g) per piece	TOTAL POLYOLS per piece (g)	PIECES FOR 6 (10) g/day	PREVENTIVE Potential ^{††}	AVAILABILITY
GUMS:					
B-Fresh Gums	0.90	0.90	7 (11)	Yes	online
BioGenesis "Xylitol Fruit Gum"	0.72	0.72	8 (14)	Yes	online
Clen-Dent Xylitol Gum	0.67	0.67	9 (15)	Yes	online
ElimiTaste "Zapp" & "Smoke Screen" gums	1.01	1.01	6 (10)	Yes	online
Emerald Forest "Ricochet Xylitol Gum"	0.72	0.72	8 (14)	Yes	online
Epic Xylitol Gum	1.06	1.06	6 (10)	Yes	online
Global Sweet Polyols "Xponent Gum"	0.70	0.70	9 (14)	Yes	online
Lumi Line (Fennobon Oy) "XyliMax Maximum Gum"	1.0	1.0	6 (10)	Yes	online
Lumi Line (Fennobon Oy) "XyliMax Gum"	0.70	0.70	9 (14)	Yes	online
Nature's Provision "Smart Smile Gum" (Xylipro)	0.70	0.70	9 (14)	Yes	online
Omnii "Theragum"	0.70	0.70	9 (14)	Yes	online
Peelu "Xylitol Gum"	1.0	1.0	6 (10)	Yes	online
Spry Xylitol Gum	0.72	0.72	8 (14)	Yes	retail & online
Tundra Trading "XyliChew Gum"	0.80	0.80	8 (13)	Yes	retail
Vitamin Research "Unique Sweet Gum"	0.72	0.72	8 (14)	Yes	online
XyloBurst Gum	1.0	1.0	6 (10)	Yes	online
Zellies "Xylitol Gum"	0.70	0.70	9 (14)	Yes	online
Altoids Sugar-Free Gum (Cinnamon/Peppermint)	2 nd of 4 polyols	1.0	NC*	Maybe	retail
BreathRx "Halispheres Sugar-Free Gum"	1 st of 3 polyols	< 1g/piece	NC	Maybe	online
Elma "MASTICgum"	0.53g (1 st of 3 polyols)	NC	11 (19)	Maybe	online
Hershey "Ice Breakers Ice Cube" Gum	1 st of 5 polyols	2.0	NC	Maybe	retail
Starbucks "After Coffee" Peppermint/Tangerine	1 st of 2 polyols	1.0	NC	Maybe	retail
Zellies "Kids Gum"	0.50	0.0	12 (20)	Maybe	online
Arm & Hammer "Dental Care Baking Soda Gum"	2 nd of 3 polyols	1.0	NC	No	retail
Arm & Hammer "Advance White Icy Mint Gum"	2 nd of 3 polyols	1.0	NC	No	retail
Biotene "Dry Mouth Gum"	3 rd of 3 polyols	1.0	NC	No	retail

PRODUCTS [†]	XYLITOL grams (g) per piece	TOTAL POLYOLS per piece (g)	PIECES FOR 6 (10) g/day	PREVENTIVE Potential ^{††}	AVAILABILITY
Cadbury Adams "S Stride" Gum	3 rd of 3 polyols	1.0	NC	No	retail
Dentyne "Tango Gum"	4 th of 4 polyols	1.0	NC	No	online
Eco-Dent "Between Dental Gum" (various flavors)	0.35	1.0	17 (29)	No	online
Ferndale "glean whitening gum"	0.05	0.7	120 (200)	No	online
Tully's "vanilla mint gum"	5 th of 5 polyols	1.0	NC	No	retail
Cadbury Adams "Trident Gum with Xylitol" (stick)	2 nd of 3 polyols	1.0	NC	No	retail
Cadbury Adams "Trident Gum with Xylitol" (pellet)	3 rd of 3 polyols	1.0	NC	No	retail
Cadbury Adams "Trident for Kids Gum"	3 rd of 3 polyols	1.0	NC	No	retail
Wrigley "Orbit Sugar-Free Gum"	3 rd of 3 polyols	1.0	NC	No	retail
MINTS:					
B-Fresh "Mints"	0.70	0.70	9 (14)	Yes	online
Clen-Dent "Mints"	0.67	0.67	9 (15)	Yes	online
Lumi Line "Sugar Free Chewy Mints"	1.0	1.0	6 (10)	Yes	online
Biogenesis "Xylitol Peppermint Mints"	0.55	0.55	11 (18)	Maybe	online
Emerald Forest "Ricochet Xylitol Mints/Sours"	0.40	0.40	15 (25)	Maybe	online
Epic "Xylitol Mints"	0.50	0.50	12 (20)	Maybe	online
Global Sweet Polyols "Xponent "Mints"	0.55	0.55	11(18)	Maybe	online
Nature's Provision "Smart Smile Mints" (Xylipro)	0.55	0.55	11 (18)	Maybe	online
Ommi "Theramints"	0.50	0.50	12 (20)	Maybe	online
OraHealth "Xylimelts" (time release formula)	0.50	0.50	12 (20)	Maybe	online
Spry "Mints"	0.50	0.50	12 (20)	Maybe	online
Tundra Trading "XyliChew Mints"	0.55	0.55	11 (18)	Maybe	retail
Vitamin Research "Unique Sweet Mints"	0.50	0.50	12 (20)	Maybe	online
XyloBurst Mints	0.50	0.50	12 (20)	Maybe	online
Zellies "Xylitol Mints"	0.50	0.50	12 (20)	Maybe	online
Mint Asure breath capsules	0.063	0.063	95 (160)	No	retail
SMINT "Mints" (Regular & White)	< 0.20	<0.20	30 (50)	No	retail
Xlear "SparX" (candy - various flavors)	0.23	0.23	25 (40)	No	online
Brown & Haley "Zingos Caffeinated Peppermints"	2 nd of 2 polyols	2.0	NC	No	retail
Hershey "Ice Breakers Center Ice" mints	1 st of 2 polyols	2.0	NC	No	retail

PRODUCTS [†]	XYLITOL grams (g) per piece	TOTAL POLYOLS per piece (g)	PIECES FOR 6 (10) g/day	PREVENTIVE Potential ^{††}	AVAILABILITY
Oxyfresh "Breath Mints"	2 nd of 2 polyols	NC	NC	No	online
Starbucks "After Coffee Mints"	2 nd of 2 polyols	<0.14	NC	No	retail

[†] Product list is not exhaustive. Xylitol market is rapidly changing and new xylitol containing products appear frequently.

^{††} The products in Table 1 (Gums and Mints) are sorted initially by their preventive potential. Products within the preventive potential groupings of "Yes", "Maybe", and "No" are listed alphabetically. "Yes", "No", or "Maybe" is based on the potential a person is willing to consume 2-3 pieces, 3 to 5 times per day to meet the effective dose range of 6 to 10 grams per day. Products with potential for effectiveness but xylitol dose is either unknown or required consumption is 10 pieces per day to provide 6 g of xylitol are assigned "Maybe".

* NC = Not Certain. Information can not be derived from internet vendor, or market packaging, or not successful in obtaining information from vendors' information representatives.

Table 2
Xylitol Containing Oral Hygiene, Healthcare, and Diet Products Available in U.S. Markets, and Their Xylitol Content

PRODUCTS*	XYLITOL Content	AVAILABILITY
ORAL HYGIENE:		
Biotene "Dry Mouth Toothpaste/Gel" (+/- Calcium)	10% (0.14% sodium fluoride)	retail & online
Crest "Multicare Cool Mint Toothpaste"	10% (0.24% sodium fluoride)	retail & online
Epic "Fluoride-Free Xylitol Toothpaste" (no F)	25%	online
Epic "Xylitol & Fluoride Toothpaste"	31% (0.24% sodium fluoride)	online
NOW "XyliWhite Toothpaste" Gel (no F)	25%	retail & online
Spry Toothpaste (no F)	25%	retail & online
Spry Toothpaste with Fluoride	25% (0.24% sodium fluoride)	retail & online
Squigle "Enamel Saver Toothpaste"	36% (0.24% sodium fluoride)	online
Tanner's "Tasty Paste" Toothpaste	15% (0.24% sodium fluoride)	online
ToothZone "Xylokid Toothpaste" (reduced F)	30% (0.55% sodium fluoride)	online
Topex Toothpaste "Take Home Care", "White Care"	10% (1.1% sodium fluoride)	dental office & online
Orajel "Dry Mouth Toothpaste"	NC ^{††} 2 nd of 2 polyols (last ingre.)	retail & online
Oxyfresh "Super Relief Gel" & Fluoride Dental Gel"	NC only sweetener (2 nd ingre.)	online
Oxyfresh "Power Paste" Toothpaste	NC 2 nd of 2 polyols (7 th ingre.)	online
Rembrandt Toothpaste "For Canker Sore"	NC only sweetener (5 th ingre.)	retail & online
Tom's of Maine Toothpaste/Gel lines except Anticavity Cinnamon & "for children" Toothpaste contain NO xylitol	1%-7% (varies in ingredient list)	retail & online
Tom's of Maine Anticavity Liquid Gel "for children"	NC 2 nd of 2 polyols (6 th ingre.)	retail & online
Tundra Trading "XyliBrush Toothpaste"	NC only sweetener (3 rd ingre.)	online
Spry Infant "Tooth Gel" (no F or flavoring)	35%	online
Gerber Infant "Tooth & Gum Cleanser" (no F)	NC 1 st of 2 polyols (3 rd ingre.)	retail & online
Gerber Toddler "Tooth & Gum Cleanser" (no F)	NC 2 nd of 2 polyols (6 th ingre.)	retail & online
Laclede "First Teeth" Baby Toothpaste (no F)	NC 1 st of 2 polyols (3 rd ingre.)	retail & online
Oral-B "Stages Baby Tooth & Gum Cleanser" (no F)	NC 2 nd of 2 polyols (6 th ingre.)	retail & online
Dr. Ray's Products "Spiffies Dental Wipes"	0.65 g/wipe (only sweetener)	online
Epic "Oral Rinse" (no F)	25%	online
Parnell "MouthKote Oral Moisturizer"	15-30%	online
Spry "Oral Rinse" (no F)	22%	retail & online

PRODUCTS*	XYLITOL Content	AVAILABILITY
Biotene "Oral Balance" Dry mouth gel or liquid	NC 2 nd of 2 polyols	retail & online
Biotene "Mouthwash"	NC 1 st of 2 polyols	retail & online
NOW "XylitolWhite Mouthwash"	NC only sweetener (2 nd ingre.)	retail & online
Oasis "Mouth Spray"	NC only sweetener (last ingre.)	retail & online
Orajel "Dry Mouth Moisturizing Spray"	NC 2 nd sweetener (7 th ingredient)	retail & online
Oxyfresh "Mouthrinses" (except Unflavored)	NC only polyol (2 nd ingredient)	online
Spry "Rain" Dry mouth spray	NC 30% by volume	online
Tom's of Maine "Anticavity (fluoride) Mouthwash"	NC (varies in ingredient list)	retail & online
ToothZone Sponge Floss (with xylitol)	NC	online
Xylifloss "Pocket Dental Flosser"	NC	retail & online
HEALTHCARE:		
Omni "Cavity Shield" 5% Sodium Fluoride Varnish	NC (only sweetener)	Rx – Dental Office
Omni "Vanish" 5% Sodium Fluoride Varnish	NC (only sweetener)	Rx – Dental Office
Sultan "DuraShield" 5% Sodium Fluoride Varnish	NC (only sweetener)	Rx – Dental office
"VanishAmerica" 5% Sodium Fluoride Varnish	NC (has sucralose)	Rx – Dental office
Bayer "Flintstone Vitamins - Complete"	NC	retail & online
Bayer "One a Day Kids Vitamins - Complete"	NC	retail & online
Jarrow Formulas "Kid Bear Kids Multi"	NC	retail & online
Micro Spray "Vitamin Sprays"	NC (2 nd ingredient)	online
NatureSmart "Disney Complete Multivitamin"	NC	retail & online
NOW Foods "Kid Cal Orange Dream"	NC	retail & online
Solgar "Kangavites Multivitamin/ Vitamin C"	NC	retail & online
Sundown "Spiderman Complete Vitamins"	NC	retail & online
B&T "Echina Spray"	NC	online
Nicorette "Gum" –Mint	NC (last ingredient)	retail & online
NOW "Activated Nasal Mist" with Xylitol	NC (2 nd ingredient)	retail & online
Xlear "Nasal Wash"	NC (2 nd ingredient)	retail & online
ENERGY BARS & FOOD:		
Barry Farm Sugar Free Jam (various flavors)	3.6 g/20 g serving (18%)	online
Barry Farm Sugar Free Pie Filling (various flavors)	45 g/serving (36%)	online
Bayho "Ultra Low Carb Bar – Chocolate Coconut	1.2 g/bar	online

PRODUCTS*	XYLITOL Content	AVAILABILITY
Buddha Bars / Vitality Bar	4 – 5 g/bar	online
Chocolate Passion “Gourmet Chocolate Sauces”	7 g/1 tbsp serving	online
Emerald Forest “Lena’s Jam” (various flavors)	12 g/1 tbsp serving	online
Emerald Forest “Chocolate Nut Bar”	7 g/bar	online
Emerald Forest “Ricochet Coffee Shots”	2 g/5 piece serving	online
Fran Gare’s “Decadent Desserts” Mix (various types)	15 – 25 g/30 g serving	online
Garden of Life “Perfect Meal” shakes	1 st “other” ingredient	retail
Glycemic Level Solutions “Glycemic MRP Shakes”	10 g/serving	online
Jarrow Formulas “Muscle Optimeal” shakes	7 th ingredient	retail & online
Jay Robb Enterprises “Egg White Protein” shakes	2 g/33 g serving	retail & online
Jay Robb Enterprises “Jaybar”	5 g/bar	online
Kraft Jell-O Pudding Sugar Free Chocolate	4–7 g/serving	retail
Nature’s Hollow (Probst) – Sugar Free Jam Preserves	4.5 g/20 g serving	online
Nature’s Hollow – Sugar Free Syrup (various flavors)	2.8 g/40 ml serving (7%)	online
Nature’s Hollow – Sugar Free Ketchup	0.8 g/20 g serving (4%)	online
Nature’s Hollow – Sugar Free Honey	1.6 g/20 g serving (8%)	online
Nature’s Way “Metabolic Reset” shakes	5 g/serving	retail & online
Renew Life Fiber35 Diet “Fit Smart” shakes	8 g/46 g serving	retail & online
Smart Sweet Xylitol Jam (various flavors)	8 g/20 g serving	online
Smart Sweet “Xylitol Maple Syrup”	9 g/40 ml (1/6 cup) serving	online
Smart Sweet “Xylitol Honey”	8 g/1 tbsp serving	online
Zipfizz energy drink (citrus & pink lemonade)	2 g/serving	retail & online

* Product list is not exhaustive. Xylitol market is rapidly changing and new xylitol containing product appears frequently. Aside from toothpaste, most products have not been studied or published in peer-review journals thus the potential impact on caries reduction is not known.

^{††}NC = Not Certain. Information can not be derived from market packaging and not successful in obtaining information from company information representative.