

## THE EFFECT OF XYLITOL TOOTHPASTE ON THE ORAL CAVITY ENVIRONMENT

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**Abstract:** The aim of this work is the clinical and laboratory evaluation of the influence of Polish toothpaste with xylitol on the condition of mouth cavity. The evidences of the last few years show that penitols, especially xylitol, are effective in the prevention of dental decay. **Material and methods.** The tests were carried out on 34 students who were divided into 2 groups: A and B with 17 students in each group. The initial clinical examination was carried out after 2 and 4 months of brushing teeth with fluoride toothpaste with xylitol (group A) and fluoride toothpaste without xylitol (group B). Clinical examination related to the evaluation of the hygienic condition of the mouth, plaque index (PLI) and hygiene index (HI), gingival index (GI), and gingival bleeding index (GBI) and Decayed Missing Filled Teeth (DMF-t) and Decayed Missing Filled Surfaces (DMF-s) was performed. **Results and discussion.** A number of 10 people from each group underwent a test on saliva secretion focusing on the number of *S. mutans* (SM) and *L. acidophilus* (LB). PH was marked, as well as the amount of saliva and the level of fluoride in saliva. No significant differences in the tested parameters were observed between the two groups. The results of the tests after 2 and 4 months of using both toothpastes pointed out the improvement of the hygienic condition of the mouth and gums. **Conclusions.** Tooth paste with xylitol had influence on the decrease of the number of *S. mutans* in saliva, the amount of secreted saliva and the increase of pH value. The use of toothpaste with xylitol as well as without xylitol caused the increase of mean values of fluoride in saliva. Xylitol added to the toothpastes has a positive influence on the quality of the oral environment and, as a result, it would be purposeful to introduce it into prophylactic programmes.

**Key words:** toothpaste, xylitol, fluoride, saliva, *S. mutans*, *L.acidophilus*

**Rezumat: Scopul** acestui studiu este evaluarea clinică și de laborator a influenței pastei de dinți poloneze care conține xilitol asupra condiției cavității bucale. În ultimii ani literatura de specialitate a arătat eficacitatea în prevenția cariei dentare a penitolilor, și în special a xilitolului. **Material și metode.** Testele au fost efectuate la un lot de 34 studenți, câte 17 studenți în două grupuri (A și B). Examinarea clinică inițială s-a efectuat la un interval de timp de 2 și 4 luni de folosire a pastei de dinți cu fluor și xilitol (grupul A) și a pastei de dinți cu fluor și fără xilitol (grupul B). S-au efectuat examinări clinice privind evaluarea condiției igienice a cavității bucale (indexul de placă- IPL și indexul de igienă- II), a gingiei (indexul gingival-IG și indexul de sângerare gingivală- ISG) și a dinților (DMF-t și DMF-s). **Rezultate și discuții.** Un număr de 10 persoane din fiecare grup a fost supus unui test asupra secreției salivare, urmărind numărul de *S. mutans* (SM) și *L. acidophilus*. (LB). Au fost determinate atât pH-ul și conținutul de salivă, cât și conținutul de fluor în salivă. Rezultatele nu au prezentat diferențe semnificative la cele două grupuri. **Concluzii.** Pasta de dinți cu xilitol a influențat

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scăderea numărului de *S. mutans* în salivă, cantitatea de salivă și creșterea valorii pH. Atât utilizarea pastei de dinți cu xilitol, cât și a celei fără xilitol au avut ca efect creșterea valorii medii a fluorului în salivă. Pasta de dinți cu xilitol a influențat favorabil calitatea mediului cavității bucale și, ca urmare, este de indicat folosirea acesteia în programele de profilaxie.

**Cuvinte cheie:** pastă de dinți, xilitol, fluor, salivă, *S. mutans*, *L. acidophilus*

### INTRODUCTION

In recent years, pentacarbon sugars, pentiols, including xylitol, are employed as supplements in preparations of oral mouth hygiene. Added to toothpaste, xylitol may not only improve taste value of the toothpaste but may influence the environment of oral cavity. Results of respective studies pointed out the cariostatic properties of xylitol, which may be linked to the inhibited development of dental plaque and to the antibacterial activity toward *Streptococcus mutans* (*SM*) and *Lactobacillus acidophilus* (*LB*), the microbes responsible for development of the decay process (1-10). The bacteria cannot metabolise xylitol and without the energy source are unable to form insoluble glucans (11, 12). Results of clinical tests related to cariostatic potential of xylitol containing toothpastes, tested on the hard dental tissues, are equivocal. Sintes et al. and Scheinin et al. have noted significantly reduced DMF-t following use of a xylitol containing toothpaste but Twetman and Peterson failed to confirm the effect. Similarly, no prevalent opinion can be noted on the effects of toothpaste contained xylitol on the levels of *SM* and *LB* (13-19).

Present study aimed at clinical and laboratory evaluation of the effects of the toothpastes containing xylitol on the condition of oral cavity.

### MATERIAL AND METHODS

The studies were performed on 34 students aging 21 to 25 years. One week before the start of the experiment, professional hygienic procedures and sanitation of oral cavity were performed, with restoration of existing dental decays. One week later preliminary examination was performed. The students received appropriate toothpastes and tooth brushes with recommendation to regularly brush their teeth twice daily using the experimental pastes. Two groups were distinguished, each containing 17 students. Students in group A brushed their teeth with fluoride toothpaste containing 9.9% xylitol while students in group B brushed their teeth with fluoride toothpaste free of xylitol. Control studies were performed following two (2<sup>nd</sup> examination) and four (3<sup>rd</sup> examination) months of tooth brushing. The studies involved clinical examination and laboratory tests.

The clinical studies included:

- a. The evaluation of oral cavity hygiene using Plaque Index (PLI) of Löe and Silness, Hygiene Index (HI) according to O'Leary (20, 21);
- b. The evaluation of the condition of the gums using Gingival Index (GI) according to Silness and Löe and Gingival Bleeding Index (GBI) according to Ainamo and Bay (22, 23);

c. The evaluation of the dentition by average numbers of DMF-t and DMF-s. The laboratory studies included:

a. The determination of fluoride level in the saliva: mixed resting saliva was collected from each student participating in the experiment in at least 2 h after breakfast. Fluoride level was established in the saliva using ion-selective fluoride electrode (Radelkis, type OP-262). Upon preliminary examination, the saliva was tested in the 30 min following toothbrushing in order to determine the maintenance of saliva fluoride level.

b. pH was estimated using pH test paper of the pH 6.2 to 8.2 range (Polskie Odczynniki Chemiczne).

c. Twenty students (10 from each group) were tested for numbers of *SM* and *LB* bacteria in their saliva using Dentocult SM and Dentocult LB tests (Vivadent), respectively.

d. The secretion of mixed saliva was stimulated with paraffin for 1 min and collected to a plastic container.

Volume of the saliva was estimated using a syringe and saliva secretion per minute was calculated.

The results of all parameters were subjected to statistical analysis, employing Spearman, Friedman tests and the contrast test. Presentation of the results included the followings: n - number of studied individuals,  $\bar{x}$  - arithmetical mean, SD - standard deviation, Me - median value. Significance of differences was tested at the confidence levels of  $p \leq 0.00001$  to  $p \leq 0.05$ .

#### RESULTS AND DISCUSSION

The mean indices of oral cavity hygiene PLI and HI are given in table 1. The mean values of the indices were found to decrease after two months of using the pastes for tooth brushing. Following 4 months (the 3<sup>rd</sup> examination) of using them a further decrease in the values took place, as compared to the preliminary examination. In particular, a decrease in mean values of dental plaque indices, PLI and HI, in group A drew our attention.

**Table 1. Mean values of PLI and HI in groups A and B**

	Group	n	Examination					
			I		II		III	
			X	SD	X	SD	X	SD
PLI	A	17*	0.81	0.39	0.58	0.26	0.39	0.25
	B	17	0.78	0.47	0.59	0.38	0.46	0.25
HI (%)	A	17*	**53.02	20.38	48.79	20.36	38.51	23.03
	B	17	**51.45	19.51	54.01	21.02	39.48	16.59

\* The studied variables were varying in time ( $p < 0.01$ , Friedman test)

\*\* The studied variables were varying in time ( $p < 0.05$  for A and  $p < 0.01$  for B)

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The mean values of the index of gingival condition are shown in table 2. In a xylitol group the respective values in consecutive examinations were 0.70, 0.45 and 0.29.

The differences between the first and the third and between the first and the second examination were significant

(test of contrasts).

The mean values of caries incidence indices DMF-t and DMF-s were similar in the two groups and amounted to 10.81, 18.44 in group A and to 10.94 and 19.37 in group B, respectively (table 3).

**Table 2. Mean values of GI and GBI indices in groups A and B**

	Group	n	Examination					
			I		II		III	
			X	SD	X	SD	X	SD
<b>GI</b>	<b>A</b>	17*	0.70	0.36	0.45	0.33	0.29	0.36
	<b>B</b>	17*	0.73	0.27	0.56	0.36	0.46	0.37
<b>GBI (%)</b>	<b>A</b>	17*	9.17	12.28	6.53	8.87	10.08	7.19
	<b>B</b>	17*	16.75	20.42	11.54	11.96	13.65	12.29

\* The studied variables significantly varying in time (p<0.01 for A and p<0.05 for B)

**Table 3. Mean values of DMF-t and DMF-s in groups A and B**

Index	Parameters	Group A (n=17)	Group B (n=17)
<b>DMF-t</b>	X	10.81	10.94
	median	11.50	12.00
	min	3.0	0.0
	max	18.0	21.00
	SD	5.05	
<b>DMF-s</b>	X	18.44	19.37
	median	17.00	20.00
	min	5.0	0.0
	max	47.00	46.00
	SD	11.39	11.84

The median values and percentages of *SM* and *LB* are presented in table 4. No significant differences were noted between *SM* and *LB* numbers in the

saliva (CFU/ml) between groups A and B. However, the changes were observed within the groups.

**Table 4. Numbers of SM and LB colonies and their distribution in groups A and B**

Groups	Median	Min	Max	% distribution according to scale				
				0	1	2	3	
Group A (n = 10)								
* SM	I	10 <sup>5</sup>	10 <sup>3</sup>	10 <sup>5</sup>	20	20	50	10
	II	10 <sup>3</sup>	10 <sup>3</sup>	10 <sup>5</sup>	40	30	30	-
	III	0.55x10 <sup>4</sup>	10 <sup>3</sup>	10 <sup>5</sup>	50	20	-	-
LB	I	10 <sup>4</sup>	10 <sup>3</sup>	10 <sup>6</sup>	60	-	20	20
	II	10 <sup>4</sup>	10 <sup>3</sup>	10 <sup>6</sup>	60	10	20	10
	III	0.55x10 <sup>4</sup>	10 <sup>3</sup>	10 <sup>6</sup>	50	10	30	10
Group B (n = 10)								
SM	I	0.55x10 <sup>5</sup>	10 <sup>3</sup>	10 <sup>5</sup>	30	20	50	-
	II	10 <sup>3</sup>	10 <sup>3</sup>	10 <sup>4</sup>	20	60	20	-
	III	10 <sup>4</sup>	10 <sup>3</sup>	10 <sup>5</sup>	20	50	30	-
* LB	I	0.55x10 <sup>5</sup>	10 <sup>3</sup>	10 <sup>6</sup>	20	30	10	40
	II		10 <sup>3</sup>	10 <sup>5</sup>	20	20	60	-
	III	0.55x10 <sup>4</sup>	10 <sup>3</sup>	10 <sup>5</sup>	50	20	30	-

Group A - \* significant variability in time (p<0.05, Friedman test)

Group B - \* variability significant at p<0.05, Friedman test ; (I vs III, test of contrast)

The mean pH of the saliva following tooth brushing with the examined pastes is shown in table 5. In the group A, the mean value of pH increased from 6.48 in the first examination to 6.73 in the second one, but then decreased to 6.63 in the third examination. Differences in pH values were not significant. In group B, the mean value of pH of the saliva increased following two months of tooth brushing and persisted at the same level following 4 months of using the fluoride toothpaste free of

xylitol. The differences between the first and the second as well as between the first and the third examination were significant.

Concerning the saliva secretion, a significant increase in saliva flow was observed between the first and the second as well as between the first and the third examination following tooth brushing using the xylitol containing toothpaste (group A). An increase was noted in mean saliva secretion also in group B, but the variability in time did not have any influence (table 6).

**Table 5. Mean pH of saliva in groups A and B**

Group	n	Examination											
		I				II				III			
		X	SD	Min	Max	X	SD	Min	Max	X	SD	Min	Max
A	17	6.48	0.27	6.0	6.9	6.73	0.35	6.0	7.3	6.63	0.33	6.0	7.2
B	17*	6.34	0.29	6.0	7.0	6.60	0.36	6.0	7.5	6.60	0.31	6.2	7.5

\* significant variability in time (p < 0.01, I vs II, I vs III)

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**Table 6. Mean flow of saliva (ml/min) in groups A and B**

Group	n	Examination											
		I				II				III			
		X	SD	Min	Max	X	SD	Min	Max	X	SD	Min	Max
A	10*	1.71	0.82	0.73	2.8	2.14	0.81	1.0	3.2	2.3	0.89	1.0	3.5
B	10	1.46	0.97	0.33	3.0	2.04	0.81	0.9	3.0	1.9	0.99	0.80	4.0

\* significant variability in time ( $p < 0.01$ , I vs II, I vs III)

The mean values of fluoride levels in the saliva are shown in table 7. In group A the saliva contained a mean of 0.08 ppm in the first, 0.12 ppm in the second and 0.18 ppm in the third examination. In group B mean fluoride content increased from 0.13 ppm in the first examination to 0.14 ppm in the second and to 0.24 ppm in the third one.

The data on the increase in saliva content of fluoride ions 30 min after toothbrushing with the studied toothpastes are shown in table 8. Both in group A and in group B, fluoride content increased from 0.08 ppm to 0.76 ppm and from 0.13 ppm to 0.77 ppm, respectively.

**Table 7. Mean fluoride levels in saliva in groups A and B**

Group	n	Examination											
		I				II				III			
		X	SD	Min	Max	X	SD	Min	Max	X	SD	Min	Max
A	17*	0.08	0.10	0.0	0.12	0.12	0.25	0.0	0.45	0.18	0.21	0.0	0.37
B	17	0.13	0.29	0.0	0.50	0.14	0.22	0.0	0.52	0.24	0.25	0.0	0.42

\* significant variability in time ( $p < 0.01$ , I vs II, I vs III)

**Table 8. Mean fluoride levels in saliva before and 30 min after tooth brushing with the evaluated pastes**

Group	n	Baseline				after 30 min			
		X	SD	Min	Max	X	SD	Min	Max
A	17	0.08	0.10	0.0	0.12	* 0.76	0.16	0.12	1.60
B	17	0.13	0.29	0.0	0.95	* 0.77	0.34	0.10	1.52

\* Differences significant for group A at  $p < 0.000001$  and for group B at  $p < 0.001$

Analysis of the obtained results upon the preliminary examination has shown that the two groups have not differed from the clinical or laboratory parameters points of view. Statistical analysis shows no significant differences in the

evaluated traits between group A and group B. Thus, the investigated material may be regarded uniform. Application of the fluoride toothpaste containing 9.9% xylitol has significantly reduced the dental plaque indices PLI

and HI in the course of the 4 months of experiment. These results are similarly to those obtained by the clinical studies following the use of a xylitol containing chewing gum (2, 4, 5, 24). As stressed in the literature, frequent introduction of xylitol to the oral cavity lead to a dental plaque containing less polysaccharides and lipoteichoic acid (14). The acid contains lipids which have a hydrophobic part easily binding to a bacterial cell and in parallel exhibiting strong affinity to enamel hydroxyapatite. In this way it is promoted the adhesion of some caries-inducing streptococci to the enamel surface (25). Xylitol decreases the amount of lipoteichoic acid and, therefore, decreases number of bacteria in the dental plaque.

In our studies the effects of xylitol-containing toothpastes have been examined on the number of *SM* and *LB* bacteria. In studies of Makinen et al and those of Svanberg et al, tooth brushing with pastes containing 9.4% xylitol participated in a significant reduction of *S. mutans* level (16, 18). Other authors, using Dentocult *SM* and *LB* tests did not observe the decrease of *SM* and *LB* levels in persons which tooth brush their teeth with the paste containing 9.7% or 3% xylitol (15, 17). Also, our studies have failed to detect significant differences in *SM* and *LB* levels between the group using xylitol-containing toothpaste and the control group. Nevertheless, a significant reduction of *SM* has been noted in group A. In group B, *LB* level has decreased. It should be specify that the studies have been performed on

students who were free of active caries. Even if the significance of differences in *SM* numbers, using Friedman's test, could not have been confirmed by the test of contrasts, the xylitol-containing toothpaste can be assumed to lead to the decrease in *SM* numbers in saliva. Possibly, using higher xylitol content in the toothpaste similar results could be obtained to those published by Makinen et al who detected a significant decrease in *SM* level after 3-month application of a tooth paste containing more than 20% xylitol (16). Biocompatibility of toothpaste components affects bio accessibility of their active ingredients. In this respect substantial attention is devoted to foaming agents. One of them is sodium laurylsulphate. It reacts with cell membrane structures of bacteria inhibiting xylitol uptake and preventing formation of xylito-5-phosphate (26). Also in our studies the foaming agent involved sodium laurylsulphate. Its presence might have caused that the time-dependent significant decrease in saliva *SM* and *LB* levels has not been confirmed by the sensitive test of contrasts. Some other authors obtained the same results, challenging the xylitol potential in affecting the ecology of oral cavity in the presence of sodium laurylsulphate (27).

Results of respective studies indicate that xylitol, particularly when it is contained in the chewing gum, stimulates saliva secretion and affects pH of the saliva (28, 29, 30).

Preventing an excessive decrease in pH of the saliva, it neutralizes the pH of dental plaque (28). In our studies

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tooth brushing with a xylitol-containing paste twice a day has induced a significant increase in saliva secretion. Also, analysis of the mean values of saliva production should be emphasized that they have fitted the normal range, which in healthy individuals amounts to 1-3 ml/min.

The toothpastes used by the students brushing their teeth for 4 months, have contained 0.24% sodium fluoride and the paste A, 9.9% xylitol in addition. Makinen et al. are of the opinion that even low xylitol concentration in fluoride toothpastes improves their cariostatic effects on tooth tissues (16). Parallel use of xylitol with small doses of F<sup>-</sup> ions may not only determine caries control but may help to avoid fluoride in children with teeth in the course of mineralization (17). Prophylactic action of fluoride compounds depends, i.e., upon trapping of fluoride ions in the mouth cavity (31). Concentration of the ions in the saliva depends upon the amount and flow rate of saliva, contractions of oral cavity muscles, frequency of eating, drinking, etc. (32). In persons who brush their teeth with fluoride toothpastes, the mean F<sup>-</sup> level in the saliva ranged between 0.01 and 0.09 ppm and activities after tooth brushing significantly affect trapping of fluoride ions in the mouth cavity (32, 33, 34, 35, 36). In the presented experiments the fluoride level in the saliva has ranged upon preliminary examination between 0.0 and 0.12 ppm in group A and between 0.0 and 0.95 ppm in group B. Following 2 and 4 months of tooth brushing with xylitol containing

toothpaste or the control toothpaste a stable increase has occurred in fluoride level in the saliva. Similarly to the data of Chmielnik et al, a significant increase in fluorides has been noted in the saliva following 30 min of tooth brushing with fluoride-containing preparations (37). Results of studies indicate that the xylitol content in the toothpaste has not counteracted the augmentation of fluoride level in the saliva, which promoted re-mineralization of early enamel lesions.

Clinical and laboratory studies indicate that the content of xylitol in the toothpaste has favorable effects on the condition of oral cavity and, therefore, it is recommended to introduce xylitol into the prophylactic programs.

### CONCLUSIONS

1. Tooth paste with xylitol had influence on the decrease of the number of *S. mutans* in saliva, the amount of secreted saliva and the increase of pH value.
2. The use of toothpaste with xylitol as well as without xylitol caused the increase of mean values of fluoride in saliva.
3. Xylitol added to the toothpastes has a positive influence on the quality of the oral environment and it would be purposeful to introduce it into prophylactic programmes.

### REFERENCES

1. Assev S, Waler SM, Röllä G: *Xylitol fermentation by human dental plaque*. Eur. J. Oral Sci. 1996, 104 (4/I): 359.
2. Cronin M, Gordon J, Reardon R, Balbo F: *Three clinical trials*

- comparing xylitol and sorbitol chewing gums for their effect on supragingival plaque accumulation.* J. Clin. Dent. 1994, 5 (4): 106.
3. Lingstrom P, Lundgren F, Birkhed D, Takazoe I, Frostell G: *Effects of frequent mouthrinses with palatinose and xylitol on dental plaque.* Eur. J. Oral Sci. 1997, 105 (2): 162.
  4. Makinen KK, Chen CY, Makinen PL, et al: *Properties of whole saliva and dental plaque in relation to 40-month consumption of chewing gums containing xylitol, sorbitol of sucrose.* Caries Res. 1996, 30 (3): 180.
  5. Tellefsen G, Larsen G, Kaligithi R, Zimmerman GJ, Wikesjo ME: *Use of chlorhexidine chewing gum significantly reduces dental plaque formation compared to use of similar xylitol and sorbitol products.* J. Periodontol. 1996, 67 (3): 181.
  6. Water SM, Rølla G, Assev S, Ciardi JE: *The effect of xylitol on plaque metabolism.* Swed. Dent. J. 1984, 8 (3): 155.
  7. Bradshaw DJ, Marsh PD: *Effect of sugar alcohols on the composition and metabolism of a mixed culture of oral bacteria grown in a chemostat.* Caries Res. 1994, 28 (4): 251.
  8. Soderling E, Trahan L, Tammiala-Salonen T, Hakkinen L: *Effects of xylitol, xylitol-sorbitol, and placebo chewing gums on the plaque of habitual xylitol consumers.* Eur. J. Oral Sci. 1997, 105 (2): 170.
  9. Vadeboncoeur C, Trahan L, Mouton C, Mayrand D: *Effect of xylitol on the growth and glycolysis of acidogenic oral bacteria.* J. Dent. Res. 1983, 62 (8): 882.
  10. Wennerholm K, Arends J, Birkhed D, Ruben J, Emilson CG, Dijkman AG: *Effect of xylitol and sorbitol in chewing gums on mutans Streptococci, plaque pH and mineral loss of enamel.* Caries Res. 1994, 28 (1): 48.
  11. Soderling E, Alaraisanen L, Scheinin A, Makinen KK: *Effect of xylitol and sorbitol on polysaccharide production by an adhesive properties of S. mutans.* Caries Res. 1987, 21 (2): 109.
  12. Loesche WJ: *The effect of sugar alcohols on plaque and saliva level of Streptococcus mutans.* Swed. Dent. J. 1984, 8 (3): 125.
  13. Sintes JL, Escalante C, Stewart B, et al: *Enhanced anticaries efficacy of a 0.243 % sodium fluoride /10% xylitol/silica dentifrice: 3-year clinical results.* Am. J. Dent. 1995, 8 (5): 231.
  14. Scheinin A, Banoczy J, Szoke J, et al: *Collaborative WHO xylitol field studies in Hungary. I. Three-year caries activity in institutionalized children.* Acta Odontol. Scand. 1985, 43 (6): 327.
  15. Twetman S, Petersson LG: *Influence of xylitol in dentifrice on salivary microflora of preschool children at caries risk.* Swed. Dent. J. 1995, 19 (3): 103.
  16. Makinen KK, Soderling E, Hurttia H, Lehtonen OP, Luukala E: *Biochemical, microbiologic, and clinical comparisons between two dentifrices that contain different mixtures of sugar alcohols.* J. Am. Dent. Assoc. 1985, 111 (5): 745.
  17. Petersson LG, Birkhed D, Gleerup A, Johansson M, Jonsson G: *Caries-preventive effect of dentifrices containing various types and concentrations of fluorides and sugar alcohols.* Caries Res. 1991, 25 (1): 74.
  18. Svanberg M, Birkhed D: *Effect of dentifrices either xylitol and glycerol or sorbitol on mutans streptococci in saliva.* Caries Res. 1991, 25 (6): 449.
  19. Trahan L, Mouton C: *Selection for Streptococcus mutans with altered*

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- xylitol transport capacity in chronic xylitol consumers.* J. Dent. Res. 1987, 66 (5): 982.
20. Løe H, Silness J: *Periodontal disease in pregnancy I. Prevalence and severity.* Acta Odont. Scand. 1963, 21 (6): 533.
  21. O'Leary TJ, Drake RB, Naylor IE: *The plaque control record.* J. Periodontol. 1972, 43 (1): 38.
  22. Silness I, Løe H: *Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition.* Acta Odont. Scand. 1964, 22 (1): 121.
  23. Ainamo J, Bay I: *Problems and proposals for recording gingivitis and plaque.* Int. Dent. J. 1975, 25 (4): 229.
  24. Gordon JM, Cronon M, Reardon RC: *Ability of xylitol chewing gum to reduce plaque accumulation.* J. Dent. Res. 1990, 69 (Spec. No): 136.
  25. Ciardi JE, Rølla G, Boven WH, Reilly JA: *Adsorption of S. mutans lipoteichoic acid to hydroxyapatite.* Scand. J. Dent. Res. 1977, 85 (6): 387.
  26. Assev S, Rølla G: *Lack of xylitol uptake by bacteria in the presence of SLS.* Caries Res. 1995, 29 (4): 297.
  27. Assev S, Waler SM, Rølla G: *Are sodium lauryl sulfate-containing toothpastes suitable vehicles for xylitol?* Eur. J. Oral Sci. 1997, 105 (2): 178.
  28. Birkhed D: *Cariologic aspects of xylitol and its use in chewing gum: a review.* Acta Odontol. Scand. 1994, 52 (2): 116.
  29. Dodds MW, Hsieh SC, Johnson DA: *The effect of increased mastication by daily gum-chewing on salivary gland output and dental plaque acidogenicity.* J. Dent. Res. 1991, 70 (12): 1474.
  30. Jenkins GN, Edgar WM: *The effect of daily gum-chewing on salivary flow rates in man.* J. Dent. Res. 1989, 68 (5): 786.
  31. Petersson LG, Ludvigsson N, Ullbro C, Gleerup A, Koch G: *Fluoride clearance of whole saliva in young school children after topical application.* Swed. Dent. J. 1987 11 (1): 95.
  32. Sjögren K: *Toothpaste technique. Studies on fluoride delivery and caries prevention.* Swed. Dent. J. Suppl. 1995, 110: 1.
  33. Duckworth RM, Morgan SN: *Oral fluoride retention after use of fluoride dentifrices.* Caries Res 1991, 25 (2): 123.
  34. Reich E: *Anti-caries efficacy.* In: Proceeding of the 2nd European Workshop on Periodontology. Thurgau, 1996, 3-6 February. Ed. Lang NP, Karring T., Lindhe J.; Quintessenz: Berlin; 1997, p 236.
  35. Edgar WM: *Fluoride concentration in saliva and plaque related to the mode of action and efficacy of fluorides.* In: Relative Efficacy of Sodium Fluoride and Sodium Monofluorophosphate as Anti-caries Agents in Dentifrices. Ed. WH. Bowen; Royal Society of Medicine Press Limited: London, 1995, p. 15-20.
  36. Kobylańska M, Magas A: *Fluoride toothpastes – an important element of caries prophylaxis.* Mag. Stomatol 1993, 3 (12): 28.
  37. Chmielnik M, Stopa J, Soboczyńska K, Kubiak D, Wojtko E: *The new Polish fluoride gel in caries prophylaxis.* Pozn. Stomatol, 1994, 22: 77.