Effect of a xylitol chewing gum on plaque quantity and quality

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The aim of the present study was to further investigate the plaque-reducing effect of a xylitol-containing chewing gum. Ninety-six dental students were divided randomly into three groups: a sucrose group (n = 32), a xylitol group (n = 36) and a control group (n = 28), using a sucrose-containing chewing gum, a xylitol-containing chewing gum, or no chewing gum, respectively, during a three-day experimental plaque growth period with restricted oral hygiene. The fresh weight of plaque collected in the xylitol group was 40 % lower than in the sucrose group, along with a significantly lower mean plaque index. The use of the xylitol chewing gum induced low invertase-like activity in plaque extra-cellular phase together with low carbohydrate content. These results concur to indicate advantageous effects through the use of a xylitol-containing chewing gum.

Key-words: Dental plaque; xylitol; sucrose; chewing gum; invertase

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The results obtained in recent short term chewing gum studies (*Mouton, Scheinin & Mäkinen*, 1975 a, b) showed that the use of a xylitol-containing chewing gum induced a significant decrease in the amount of plaque as well as in the invertase-like activity of the water-soluble phase of plaque. However, results at variance with the gravimetric method used in assessing the amount of plaque were obtained by using a stained plaque scoring system on the buccal aspect of the teeth appearing in intraoral macrophotographs. The eventual inadequacy of such a plaque scoring system was discussed. The psychological influence of the experiment, extending over four weeks and involving repeated periods with restricted oral hygiene was also noticed. It affected the behaviour of the subjects, kept on their usual diet, to modify their consumption of sucrose-containing products, thus possibly leading to erroneous understanding of the variations in the amount of plaque.

It was thus decided to further investigate the effect of the xylitol-containing chewing gum on plaque formation by using a different methodological approach, enabling a comparison with the previous studies. Furthermore, it was decided to study the water soluble fraction of carbohydrates and the invertase-like activity in individual and pooled plaque samples.

MATERIAL AND METHODS

Ninety six dental students (74 females and 22 males), aged 19—25 years, acted as

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Table I. *The chewing schedule; each stick to be chewed for 10 minutes*

	Sticks
At awakening	1
After 1st meal	2
After 2nd meal	2
At bedtime	1
Total	6

voluntary subjects in this investigation. They were randomly divided into three groups: 1) a group involved in a sucrose-containing chewing gum test (32 individuals), 2) a group involved in a xylitol-containing chewing gum test (36 individuals), 3) a group not involved in a chewing gum test, acting as a control group (28 individuals).

The experiment consisted of two phases: a plaque growth period, and a clinical registration. The plaque growth period started on the first morning after thorough toothbrushing, and lasted for three days during which the subjects were requested to refrain from all oral hygiene procedures. During the plaque growth period the subjects belonging to the S- and X-groups were instructed to chew six pieces of gum per day according to written instructions as recorded in Table I. The subjects were provided with a 18 stick supply of sucrose (S-) or xylitol (X-) containing chewing gum. On the fourth morning, the plaque growth period ended with a clinical registration consisting of a plaque index assesment, plaque collection, and intraoral photography.

Plaque Index. Plaque was scored according to the Plaque Index (Pl I) system of *Silness* and *Löe* (*Löe*, 1967) from the four gingival areas of six teeth: 16, 12, 24, 44, 32, 36 and a mean Pl I value for the individual was calculated.

Plaque collection and net weight assessment. Plaque was collected from the right halves of the dentition only, separately for the upper and lower jaw, and immediately weighed. Thus the plaque fresh weight was determined separately for the upper (PFW_u) and the lower jaw (PFW_l), the sum giving the plaque fresh weight (PFW) for the individual. The material obtained from each test-person was then suspended into 1.0 ml cold (4° C) 0.9 % sodium chloride solution, and stored for further laboratory procedures.

Biochemical assays. Each individual plaque sample, suspended into 1.0 ml of 0.9 % cold NaCl-solution, was stirred for 2 min with a glass rod. The mixtures were centrifuged for 10 min at 23500 × g at 4° C. The resulting supernatant fluids were analysed for protein (Folin-Ciocalteu method, with bovine serum albumine as standard) and invertase-like activity. The results were expressed as mg protein per ml, and as μmole of liberated reducing sugars per minute and per mg proteins, respectively. A more detailed description of the methods has been previously published (*Scheinin & Mäkinen*, 1971).

The remaining of the supernatant fluids were then pooled according to the grouping, and each one of the three pools was analysed for protein, invertase-like activity and total sugars. The total sugar assay was performed on 0.5 ml of the supernatant fluid, using the anthrone method (*Scott & Melvin*, 1953) and D-glucose as standard. The results were expressed as μg of glucose equivalent per ml of the above supernatant fluid, and for better comparison, the ratio to the quantity of plaque (in mg) was calculated.

Although this experiment was designed as a double-blind study, it must be noticed that knowledge of the nature of the products tested might have occurred in some subjects. This might have taken

place through exchange of information with regard to a subtle difference in taste between S- and X-chewing gum, and subjectively experienced difference in plaque formation. Nevertheless, until the data obtained from the clinical registration were analysed, the investigators were not aware of the group the subject belonged to.

RESULTS

Gravimetric data. Table II shows the gravimetric values obtained for the three groups. The lowest amount of plaque was obtained from the group using the X-containing chewing gum, the highest amount from the group using the S-containing product. Comparison between these values indicate that there was 40 % less plaque in the X-group than in the S-group (significant difference at the 0.05 level, two-sided Mann-Whitney U-test), and 24 % less plaque in the X-group than

Table II. *Quantitation of plaque in terms of gravimetric assessment in mg and plaque index values*

PFW: total plaque fresh weight
PFW_u: plaque fresh weight upper jaw
PFW_l: plaque fresh weight lower jaw
Pl I: Silness and Löe plaque index

		PFW	PFW_u	PFW_l	Pl I
Control group n = 28	Minimum	7.4	2.2	3.0	1.08
	Maximum	86.5	40.7	45.8	1.91
	Median	32.5	13.3	16.2	1.52
	$\bar{x}$	33.4	15.0	18.4	1.49
	S.D.	18.6	9.5	11.5	0.24
Sucrose group n = 32	Minimum	15.2	4.1	6.2	0.91
	Maximum	135.6	52.6	83.0	2.16
	Median	38.1	16.8	18.2	1.62
	$\bar{x}$	42.2	19.0	23.2	1.60
	S.D.	24.1	10.9	15.8	0.28
Xylitol group n = 36	Minimum	3.6	0.6	2.2	1.0
	Maximum	97.6	54.6	43.0	2.37
	Median	23.4	9.8	11.2	1.41
	$\bar{x}$	25.2	11.5	13.7	1.43
	S.D.	18.0	9.9	9.7	0.25

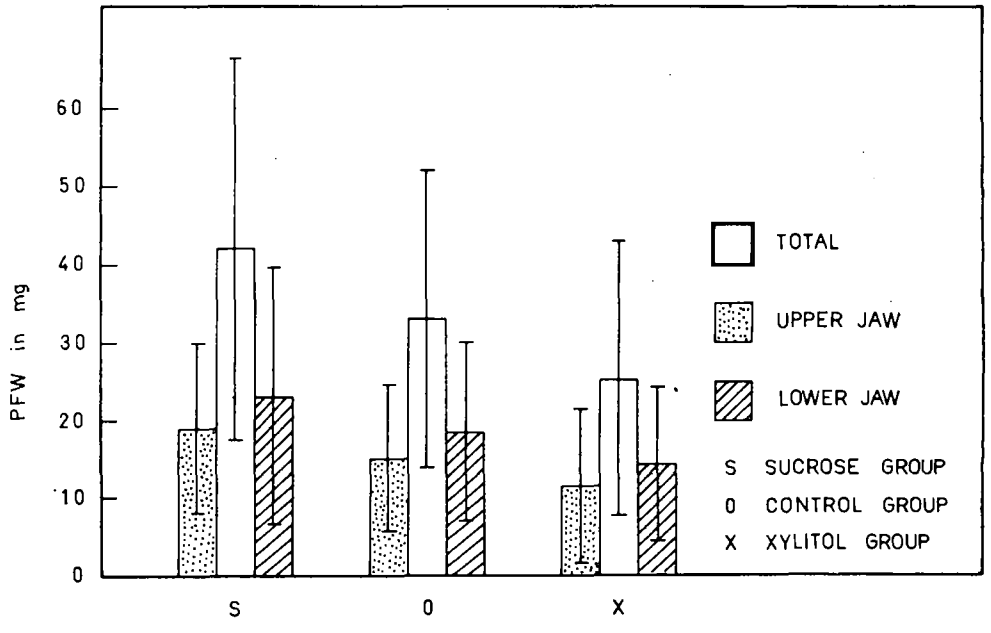

Fig. 1. The means and standard deviations of the gravimetric recordings for the three groups. Comparison between the sucrose and the xylitol groups: $p < 0.05$.

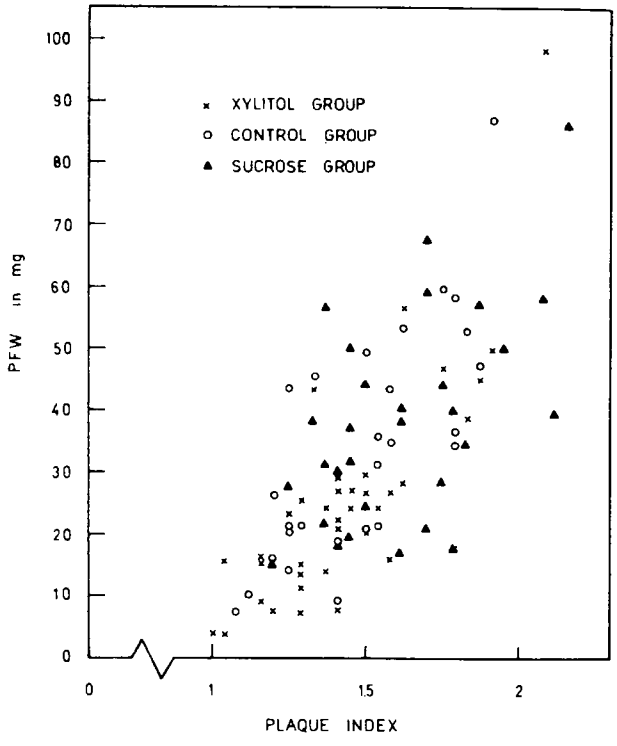

Fig. 2. The correlation between plaque index (Pl I) and the fresh weight of plaque (PFW): $p < 0.05$ (Kendall rank correlation test.)

in the control group (not significant). In the S-group there was 27 % more plaque than in the control group (not significant). In the three experimental groups, the plaque fresh weight of the lower jaw (PFW_l) was higher than in the upper jaw (PFW_u) (Fig. 1); this difference was significant in the control group. ($p < 0.05$, two-sided Wilcoxon pair test) and not significant in the S- and X-groups. The 40 % difference between PFW of the S- and the X-groups was also noticed with regard to PFW_u and PFW_l, and found significant in both cases at the 0.05 level.

Plaque index. The findings are summarized in Table II. The lowest mean Pl I value was found in the X-group and the highest in the S-group. A comparison between the individual Pl I values for the three groups was made by using non-parametric methods (Kruskal-Wallis test, followed by the Mann-Whitney U-test); the difference between the S- and the X-groups was found significant at the 0.05 level.

A study of the correlation between the individual Pl I and PFW values (Kendall rank correlation test) showed a significant correlation at the 0.05 level in the three groups (Fig. 2). A significant correlation was found with regard to PFW_u and PFW_l as well. A correlation study was also made between the individual frequencies of Pl I score 2 (*Birkeland & Jorkjend*, 1973) and PFW; a significant correlation at the 0.05 level (Kendall rank correlation test), was obtained with regard to the control group and the X-group, but not in the S-group.

Biochemical data. Table III shows the invertase-like activity values obtained 1) by calculating the means and standard

Table III. *Invertase-like activity (in μmole/min × mg protein) of individual and pooled samples of plaque aqueous extract*

		Individual samples	Pooled samples
Control group (28 samples)	$\bar{x}$	0.360	0.245
	S.D.	0.368	
Sucrose group (32 samples)	$\bar{x}$	0.408	0.251
	S.D.	0.320	
Xylitol group (36 samples)	$\bar{x}$	0.208	0.235
	S.D.	0.176	

Table IV. *The content of water soluble carbohydrates in the pooled samples of plaque of the three groups*

	μg Glucose/mg pooled supernatant fluid	μg Glucose/mg plaque (wet weight)
Control group (n = 28)	64	1.91
Sucrose group (n = 32)	112	2.65
Xylitol group (n = 36)	60	2.38

deviations of the individual samples in the three groups; 2) after pooling of the individual samples within each test-group before the analysis. Thus for each group two intertase-like activity values are to be considered. The X-group yielded the lowest and the S-group the highest values. The differences were found significant at the 0.05 level (Kruskal-Wallis test and Mann-Whitney U-test) with respect to X versus S, and X versus control. The assay of the water-soluble fraction of carbohydrates of plaque gave values expressed as μg of glucose per ml of extracellular aqueous phase of plaque and μg of glucose per mg of plaque (Table IV).

DISCUSSION

All the present results concur to indicate advantageous dental effects through the use of a X-containing chewing gum as compared to a S-containing chewing gum. These effects consist of a diminished formation of plaque (low weight of plaque, low plaque index), with decreased potentially pathogenic qualities (low sucrose splitting enzymatic activity, low content of soluble carbohydrate). The present findings corroborate and complete the results obtained in previous studies (*Mouton, Scheinin & Mäkinen*, 1975 a, b).

The increased plaque formation following the ingestion of frequent quantities of sucrose has already been emphasized (*Carlsson & Egelberg*, 1965; *Drummond, Nizel & Sinskey*, 1972; *Grenby, Powell & Gleeson*, 1974). The present result is nevertheless at variance with that obtained by *Folke, Gawronski, Statt & Harris* (1972), who stated that the dietary sucrose level had no apparent effect on plaque quantity. Such a controversial result might be explained by the fact that these authors selected as subjects high plaque formers only. The same authors also claimed biochemical alterations of plaque quality, including a decrease in invertase activity during the sucrose-rich diet. This result is seemingly contradictory to our findings. The discrepancy may be related to the use of different methods in expressing the enzymatic activity. *Folke et al.* (1972) expressed the invertase activity as mg glucose-equivalent produced per hour and per mg plaque wet weight, whereas the method used in the present study expressed the invertase-like activity as μmole of reducing sugars liberated per min and per mg protein, i.e. in terms of specific activity. The latter procedure is considered more reliable,

as it concerns only the protein content of plaque extracellular phase.

The assay of the total sugars of the water-soluble fraction of plaque indicates a twofold higher content in the sucrose group than in the xylitol group, when expressed as μg glucose per ml supernatant fluid, but an almost similar content in both groups when expressed as a ratio to the quantity of plaque. One should consider as obvious that the higher the amount of plaque, the lower the ratio becomes. This is the case in the sucrose group.

The plaque fresh weight of the lower jaw was constantly found to be higher than that of the upper jaw. Whether or not this difference, found significant in the control group only, might have been lessened by the use of gum, cannot be explicited here; anyhow such a lowering appears so minute that it is not given further consideration.

The suggestion by *Birkeland & Jorkjend* (1973) to express the plaque situation in each individual by the number of Pl I score 2 was tested in the present study. An attempt was made to correlate the results thus obtained with the gravimetric data, which indicated a significant correlation both in the X- and the control groups, but not in the S-group. It is likely that the high incidence of Pl I score 3 in the S-group contributes largely to give high mean Pl I values well corresponding with the gravimetric data, whereas this plaque situation is omitted if only Pl I score 2 are retained. Therefore, the above method, which does not express the plaque situation on an equal basis for the three experimental groups, cannot be considered of value in the present study.

On the other hand, the significant correlation constantly found between the individual plaque fresh weight measurements (upper jaw, lower jaw and total PFW) and plaque index values, tends to prove that such a combination would be the method of choice, in the assessment of the quantity of plaque, as suggested by *Loesche & Green* (1972).

It is concluded that plaque formed in relation to consumption of xylitol-containing chewing gum, exhibits a low ability to handle sucrose (low invertase-like activity), and that it is characterized by a low content of soluble carbohydrates. Such properties must be considered of value in the scope of caries prevention.

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