Quantification of incipient approximal caries during fructose and sucrose consumption

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The purpose of this study was to quantify the changes in the size of approximal caries lesions during regular sucrose or fructose consumption. The material consisted of the subjects in the 2-year Turku Sugar Study, with an observation period of 19 months. Planimetric evaluation showed a highly significant increase in the approximal lesions of both groups. There was no difference between the groups in the rate of the increase in the sizes of the lesions. Initially, small lesions increased at a higher rate than initially large lesions in both groups. It is concluded that a fructose diet enhances the progression of carious lesions as much as a sucrose diet. □ *Cariology; enamel caries; planimetry*

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Fructose has been considered a less cariogenic sugar than sucrose. In the Turku Sugar Studies (1) the DMFS index was about 30% lower in the fructose group than in the sucrose group (1). The microbiologic studies showed that *Streptococcus mutans* was able to ferment both fructose and sucrose (2). The acid production from fructose was of the same magnitude as from sucrose (3, 4). A mouth rinse with fructose induced a fall in plaque pH similar to that for rinses with equimolar concentrations of sucrose or glucose (5). It was thus probable that the caries development during fructose consumption would follow the same pattern as that for sucrose. Animal experiments comparing the cariogenicity of sucrose, fructose, and glucose have given conflicting results. Gustafson et al. (6) and Colman et al. (7) found higher caries indices for monkeys fed a fructose diet than for those fed sucrose or glucose diets. The aim of this study was to measure the changes in the size of carious lesions during long-term fructose or sucrose consumption.

Materials and methods

The material consisted of the subjects of the fructose and sucrose groups in the 2-year Turku Sugar Study (1). Only those subjects whose carious lesions were not filled during the study and whose lesions were detected at all three radiographic examinations (0, 12 and 19 months) were included. The number of such subjects with approximal caries was 26 in the sucrose group and 12 in the fructose group. Since the number of subjects with carious lesions in the fructose group was low at the end of the 2-year study, the last measurements of the lesions were made at the 19 months' examination.

The size of the lesions was measured planimetrically on bitewing films, as reported earlier (8–10). The size of secondary carious lesions was not measured. Four bitewing radiographs, two on each side, were taken with a standardized method, and the films were developed under standardized conditions.

The size of the lesions on distal surfaces of the canines and those on mesial and distal surfaces of premolars and first and second molars was recorded. The radiographs were coded before the planimetry so that at the time of analysis I did not know from which group, subject, and phase of the study the lesion stemmed.

Statistical methods

The absolute and systematic method errors were measured in the earlier experi-

Table 1. The number of caries-free (O), filled (F), missing (M), overlapping or unreadable (–), and carious (C) approximal tooth surfaces. Numbers are given in the beginning (0 months) and the end (19 month) of the follow-up study for sucrose and fructose groups

Sucrose (n = 33)			Fructose (n = 35)		
0 months		19 months	0 months		19 months
		O 316			O 290
		C 17			C 24
O 394	→	F 7	O 406	→	F 41
		– 54			– 51
		C 93			O –
C 149	→	O 4	C 173	→	C 30
		F 43			F 123
		– 9			– 20
– 189	→	O 60	– 196	→	O 23
		C 22			C 28
		F 11			F 13
		– 96			– 132
F 381	→	F 381	F 404	→	F 404
M 75	→	M 75	M 81	→	M 81

ments, in which the same planimetric method was used (8–10). The changes in lesion size within the group were analyzed with the analysis of variance, and the change between the groups with analysis of covariance.

Results

Altogether 114 carious lesions in 26 subjects (4.4 lesions per subject; range, 1–12) in the sucrose group and 54 lesions in 12 subjects (4.5 lesions per subject; range, 2–13) in the fructose group were observed in this study. The changes in the studied surfaces are shown in Table 1, and the progression of the carious lesions during the 19-month observation period in Fig. 1. Only those lesions that did not overlap in any of the three radiographic examinations and which were not filled during the study were included in the results.

The difference between the groups was not significant at the beginning of the study. In both groups the increase in the lesion size was linear (Fig. 1). Between 0 and 19 months the increase in size was highly significant in both groups ($p < 0.001$). In the fructose group one subject had an unusually high increase in the size of his lesions. When this subject was excluded from the analyses, no difference between the groups was found in the rate of progression of the mean lesion size. When this subject was included, the rate was higher in the fructose group ($p < 0.016$, analysis of covariance).

When the size of the lesions was compared between initially large and small (more or less than 0.5 mm^2) lesions, the increase in small lesions was greater than in large lesions ($p < 0.01$ in the sucrose group and $p < 0.005$ in the fructose group when the extreme subject was excluded). The changes in the size of lesions between subjects with many lesions did not differ from those in subjects with only a few lesions (data not shown).

There was no difference in the distribution of the cavities between the groups (Table 2).

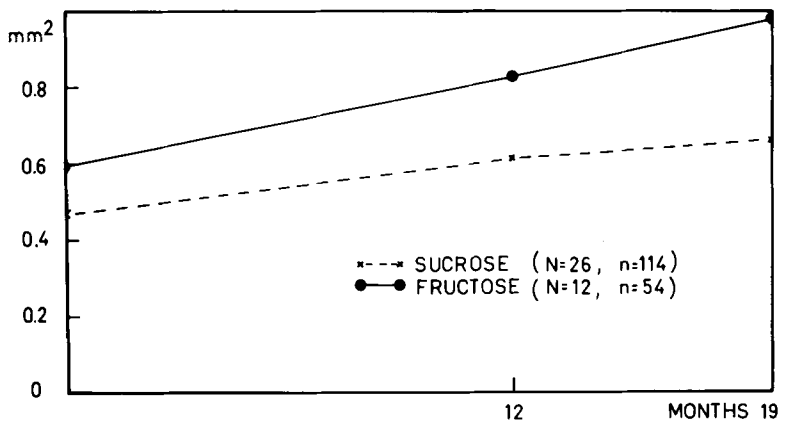

Fig. 1. Progress in the mean lesion size (mm^2) during the 19-month observation period in the fructose and sucrose groups. N = number of subjects with approximal caries lesions at 0, 12, and 19 months; n = total number of lesions.

Table 2. The frequency distribution of the carious tooth surfaces in the fructose and sucrose groups. Both sides of the upper and lower jaw are included

	Tooth surface								
	3^4	4^2	4^4	5^2	5^4	6^2	6^4	7^2	7^4
Maxilla									
Fructose	0	0	3	7	5	6	2	2	0
Sucrose	5	4	5	10	5	8	9	5	3
Mandible									
Fructose	0	0	5	4	4	6	5	5	0
Sucrose	1	1	11	8	10	6	9	11	3

Discussion

The number of newly filled surfaces was greater in the fructose group than in the sucrose and xylitol groups during the 2-year study (1). It was therefore difficult to measure the changes in the size of the lesions during the study, because many fillings replaced carious lesions. Most fillings in the fructose group were made during the last 5 months of the 2-year study period; the observation period was therefore limited to 19 months in this planimetric study.

Zamir et al. (11) found that 12% of the initial and 15% of the more advanced lesions did not change during their 36-month observation period. In the material of Berman & Slack (12), whose subjects were 11 years old at the beginning of the study, 50% of observed enamel lesions did not progress during the 3-year study. They showed that the initiation of lesions is more prominent than the progression of lesions. In my study 40% of lesions in the sucrose group and 24% in the fructose group did not increase in size; some even decreased. These results agree with those of Schwartz et al. (13), who found that 40% of lesions did not progress in 4 years.

The mean size of the carious lesions increased in both groups. This disagrees with the results of the original Turku Sugar Study, in which the subjects who belonged to the fructose group developed about 30% less carious surfaces than the subjects in the sucrose group when the DMFS index was used. However, during the 2-year study using the DMFS index the increase in the size of all lesions, especially the changes from C_1 to C_2 and CR_1 to CR_2, was as high in the fructose group as in the sucrose group. It is obvious that the use of the DMFS index and of the planimetric area is not fully comparable.

In my study the initially small lesions progressed faster than the large lesions. Granath et al. (14) have reported similar results. Gröndahl et al. (15), however, could not confirm that the rate of progression is related to the size of the lesion. When the results of many studies are compared, it must be kept in mind that the use of fluoride, the age, and the caries activity of the subjects have not been the same in different studies.

In conclusion, the results of the changes in lesion size indicate that the fructose diet increased the size of carious lesions as much as the sucrose diet.

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