Turku sugar studies

I. An intermediate report on the effect of sucrose, fructose and xylitol diets on the caries incidence in man

ARJE SCHEININ, KAUKO K. MÄKINEN &
KALEVI YLITALO

Departments of Cariology, Oral Biochemistry and Oral Radiology, Institute of Dentistry, University of Turku, Finland

Scheinin, A., Mäkinen, K. K. & Ylitalo, K. Turku sugar studies I. An intermediate report on the effect of sucrose, fructose and xylitol diets on the caries incidence in man. *Acta Odont. Scand.* 32, 383—412, 1974.

The present report covers the results after the first year of a 2-year trial, carried out in order to evaluate eventual differences in the caries incidence as influenced by sucrose (S), fructose (F) and xylitol (X) consumption. The initial material comprised 125 persons, mean age 27.5 yrs., divided according to individual preference and randomly into three groups. The S-group included 35, the F-group 38, and the X-group 52 persons, the latter group rendered oversize due to fear of loss of material. Initially no significant differences were found between the groups with regard to age, sex, number of primary and secondary carious surfaces with and without defect, number of filled surfaces and extracted teeth, and the DMFS-index. During the first 12 months of diet only 1 participant in the X-group discontinued due to diarrhoea. In addition, 2 were excluded due to lack of co-operation. Caries activity was expressed in quantitative, qualitative and combined terms through clinical and radiographic assessment. Irrespective of these methods, the caries incidence, expressed as difference between positive and negative reversals, new fillings, and increase in lesion size was lowest in the X-group, the difference as compared to the S-group being highly significant, and close to 90 %. The F-group incidence was 25 % lower than in the S-group. The results showed a dramatical reduction of the caries incidence in the X-group and indicated a therapeutic and remineralizing effect on dental caries.

Key-words: Dental caries incidence; sucrose; fructose; xylitol; prevention of dental caries

Arje Scheinin, Institute of Dentistry, University of Turku, SF-20520 Turku 52, Finland

Recently, considerable interest has been focused on the search for sucrose substitutes which have been reviewed relative to toxicity, taste, manufacture and cost in addition to the dental aspects involving cariogenicity, biochemical effects and influence on the oral microflora (*Mäkinen*, 1972; *Newbrun*, 1973; *Scheinin*, 1973). The background, indicating the necessity of the present long term trial, may thus be found in reports showing marked differences between various natural sugars with regard to their catabolic breakdown products (*Mäkinen*, 1972), cariogenicity in animal experiments (*Frostell et al.*, 1967; *Mühlemann et al.*, 1970; *Karle & Büttner*, 1971),

Received for publication, June 17, 1974.

and the physical properties and chemical composition of plaque and saliva (*Carlsson & Egelberg*, 1965; *Hassell*, 1971; *Mäkinen & Scheinin*, 1971, 1972; *Scheinin & Mäkinen*, 1971, 1972). On the other hand, little information has been available regarding the corresponding long term effects, particularly in man. The present authors thus decided to study the incidence of dental caries during a 2-year period in relation to diets selective regarding the intake of sugars only. In the present paper which is an intermediate report after one year of sucrose, fructose and xylitol intake, the results will be reported for with regard to the clinical and radiographic findings.

MATERIAL AND METHODS

The initial material in this part of the study consisted of 125 test persons (Table I), selected on the basis of the following criteria: 1) Voluntary participation, 2) cooperation in adherence to dietary regime, 3) willingness to yield to a series of comprehensive blood- and other tests, 4) residence in or close to Turku, and 5) refrain from fluoride prophylactics during the study.

Table I. *Distribution of initial material according to age and sex*

Sex	N	Age (years) $\bar{x}$	S.D.	Range
Male	44	28.3	7.0	17.0—47.0
Female	81	27.1	7.0	12.0—53.0
Total	125	27.5	7.0	12.0—53.0

Age (years)	Male	Female	Total
<15	0	1	1
15—20	2	5	7
21—26	21	43	64
27—32	11	15	26
33—38	6	12	18
39—44	2	2	4
≧45	2	3	5

On the other hand, the test persons were instructed not to change their dietary habits with regard to amount and frequency of intake of sugar-containing products. The consumption of these products was thus expected to vary considerable. A comprehensive diary was to be kept in order to measure the frequency and amount of intake on a daily basis.

The nature of the investigation excluded the possibility of conducting it as a double-blind study, the slight differences in taste and texture between sucrose, fructose and xylitol soon providing the information to the test persons. The study was, however, carried out as a blind study, the clinical (A.S.) and radiographic (K.Y.) examiners not being aware of the group the individual participant belonged to. In addition, the radiographic analysis was carried out without the examiner meeting the test persons.

In view of the nature of the study, particularly the anticipated importance of cooperation and the single-blind technique, all test persons were offered the possibility to belong to one of the specific sugar groups. By these means slightly more than 50 % of the participants were allotted to the respective groups, the remaining part being distributed at random. The grouping was carried out by one of the authors (K.M.), without knowledge of the dental conditions. In order to allow for eventual stratification, a comparison was carried out between the groups immediately after the clinical and radiographic baseline registrations. The variables thus compared, formed part of the experimental parameters, as separately described subsequently. No significant differences were, however, found between the groups with regard to these variables,

Table II. *Caries prevalence indices at baseline examination*

	Fructose			Sucrose			Xylitol		
	N	$\bar{x}$	S.D.$_f$	N	$\bar{x}$	S.D.$_s$	N	$\bar{x}$	S.D.$_x$
Primary caries without defect (C 1)	38	6.29	4.29	35	6.03	3.17	49	6.60	3.91
Primary caries with defect (C 2)	38	1.53	5.50	35	0.32	0.64	49	0.88	3.01
Secondary caries without defect (CS 1)	38	0.92	1.28	35	0.94	1.15	49	1.08	1.18
Secondary caries with defect (CS 2)	38	0.21	0.47	35	0.21	0.54	49	0.32	1.32
Additional radiographic primary caries without defect (CR 1)	38	3.32	2.88	35	2.32	2.00	49	3.56	2.96
Additional radiographic secondary caries without defect (CSR 1)	38	0.18	0.46	35	0.15	0.36	49	0.06	0.24
Additional radiographic primary caries with defect (CR 2)	38	1.21	1.66	35	1.09	1.56	49	1.02	1.24
Additional radiographic secondary caries with defect (CSR 2)	38	0.29	0.61	35	0.12	0.41	49	0.26	0.53
Total clinical caries (C 1 + C 2 + CS 1 + CS 2)	38	8.95	7.65	35	7.50	3.96	49	8.88	6.90
Total clinical and radiographic caries (C 1 + C 2 + CS 1 + CS 2 + CR 1 + CR 2 + CSR 1 + CSR 2)	38	13.95	8.75	35	11.18	5.37	49	13.78	8.07
Filled surfaces (F)	38	29.26	12.78	35	29.18	12.85	49	29.84	14.15
DMFS-index	38	47.74	14.27	35	44.00	16.69	49	50.66	18.34
Age	38	26.49	4.39	35	27.00	5.94	49	28.88	9.02

i.e. age of male participants, age of female participants, primary incipient (C 1) and advanced (C 2) carious surfaces, secondary incipient (CS 1) and advanced (CS 2) carious surfaces, filled surfaces (F), number of extracted teeth, and the DMFS-index. Table II shows the baseline values, less 3 participants in the X-group, excluded for reasons given in the results section. Despite the slightly lower number of clinically and radiographically detected carious surfaces in the sucrose (S-) group as compared to the fructose (F-) and xylitol (X-) groups (Fig. 1), but in view of this difference being not significant, no stratification between the groups was carried out.

The three groups differed in size, 35 individuals being allotted into the S-group, 38 individuals in the F-group, and 52 individuals in the X-group, the latter rendered deliberately oversize due to fear of loss of material during the study.

Methods of clinical examination. The test persons were examined in random order at each of the six registrations carried out during the first year of the trial. A constant source of artificial light was employed, and the teeth kept dry with compressed air. The clinical registration of dental caries was conducted in terms of tooth surfaces, primary (C) and secondary (CS) carious surfaces being recorded as separate entries and classified according to severity through ranking into incipient (1), and advanced (2) classes.

A lesion was diagnosed as incipient caries (C 1 or CS 1) when there was a chalky or additionally discoloured staining indicating a demineralization of the tooth surface or subsurface structure. In addition, fissures, *foramina coeca* and margins

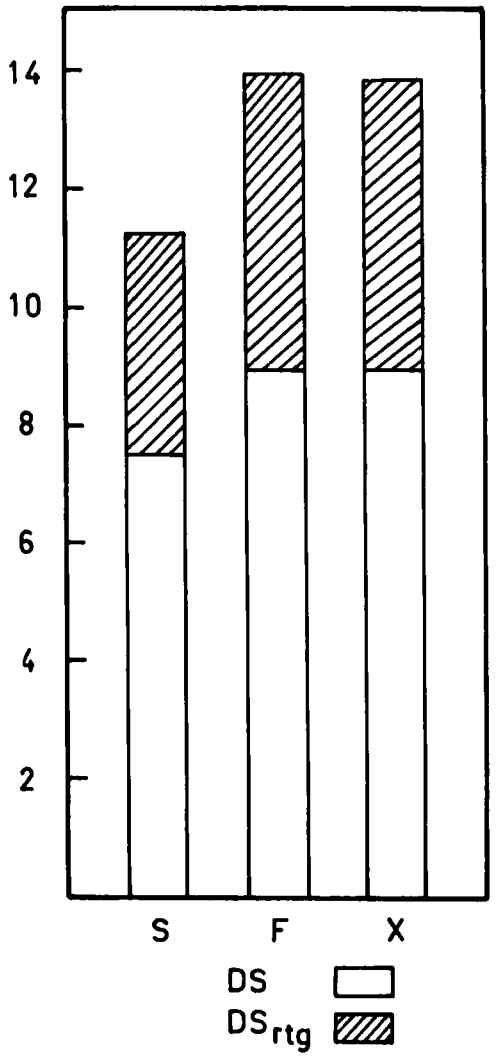

Fig. 1. Number of decayed tooth surfaces at baseline examination. Open bars denote clinically detected carious surfaces, hatched bars additional radiographically detected carious surfaces.

of fillings capable of holding an explorer point, but showing no sign of cavity formation, were recorded as C 1 or CS 1 lesions. Loss of substance, resulting in cavity formation as defined underneath, indicated classification as a C 2-lesion. Developmental disturbances and hard superficially stained tooth surfaces were not recorded as caries, but notice was taken of the location of these findings.

An advanced (C 2) lesion included all visible loss of substance, including interproximal cavity detection through the sticking of a PRO FT 12*) explorer, used for no more than two times before. In doubtful cases a completely new explorer was used. Abrasion, attrition, erosion and tooth fractures were not recorded as caries.

The fillings (F) were recorded on a tooth surface basis, the fillings as well as caries in fissures extending to the buccal and palatal (lingual) surfaces of the teeth being counted as covering the occlusal surface only. A surface both filled and carious was coded as carious. On the other hand, a surface with a defective filling but no evidence of caries was coded as filled (COCSTOC, 1973).

The extracted teeth were coded by considering the reason for missing teeth in each separate case. The following entries were thus established: a) Congenitally missing, b) not erupted, c) extracted due to difficult eruption (pericoronitis), d) extracted for reasons other than caries, and e) extracted due to caries. After the clinical recording, the teeth (15 to 25, 45 to 35) were inspected in a stereomicroscope, magnification 16×, according to the method described by *von der Fehr, Löe & Theilade* (1970). A complete recording, including additionally quantitation of plaque and collection of plaque and saliva as described separately (*Mäkinen & Scheinin*, 1974), comprised generally ca. 60 minutes.

Radiographic methods and diagnostic criteria. Four bitewing radiographs (Kodak Ultra-Speed), two of each side,

* Ash, England

Table III. *Development of primary carious lesions without defect. Clinical C 1-type reversals and net increment*

		Sucrose					Fructose					Xylitol				
	Term	R_s	Md	N	$\bar{x}$	S.D.$_s$	R_f	Md	N	$\bar{x}$	S.D.$_f$	R_x	Md	N	$\bar{x}$	S.D.$_x$
	2	0— 9	2.0	33	2.3	2.10	0— 8	2.0	38	2.2	2.0	0— 6	1.5	49	1.8	1.44
Positive	3	0—10	2.0	35	2.3	2.28	0— 7	1.0	38	2.0	2.1	0— 6	1.0	49	1.4	1.62
reversals	4	0— 7	1.0	35	1.7	2.05	0— 7	1.0	38	1.5	1.7	0— 8	1.0	49	1.0	1.49
0 → C 1	5	0— 8	1.0	35	1.6	1.92	0— 7	1.0	38	1.2	1.4	0— 2	0.0	49	0.4	0.61
	6	0— 5	1.5	35	1.7	1.40	0— 7	1.0	38	1.7	1.8	0— 4	0.0	49	0.6	0.92
	2	0— 6	1.5	33	1.9	1.76	0—10	1.0	38	1.8	2.1	0— 8	1.0	49	1.6	1.64
Negative	3	0— 4	1.0	35	1.2	1.14	0— 8	1.0	38	1.8	1.7	0— 5	1.0	49	1.6	1.53
reversals	4	0— 5	0.0	35	0.8	1.17	0— 5	1.0	38	1.1	1.3	0— 6	0.5	49	1.1	1.60
C 1 → 0	5	0— 5	1.0	35	1.1	1.39	0— 4	1.0	38	1.1	1.1	0— 4	0.0	49	0.7	1.04
	6	0— 3	0.0	35	0.5	0.83	0— 3	0.0	38	0.5	0.7	0— 7	0.0	49	0.3	1.04
Cumulative	2—3	0—16	4.0	35	4.5	3.39	0—11	4.5	38	4.2	3.3	0—10	2.5	49	3.2	2.52
positive	2—4	0—20	5.5	35	6.2	4.66	0—15	6.5	38	5.7	4.4	0—16	4.0	49	4.2	3.35
reversals	2—5	0—23	7.0	35	7.9	5.54	0—17	7.0	38	6.9	5.2	0—17	4.0	49	4.7	3.55
0 → C 1	2—6	2—24	8.0	35	9.6	6.04	1—24	8.5	38	8.7	6.4	0—19	5.0	49	5.3	3.71
Cumulative	2—3	0— 8	3.0	35	2.9	2.03	0—11	3.0	38	3.6	3.0	0—12	3.0	49	3.2	2.58
negative	2—4	0— 8	3.5	35	3.7	2.31	1—14	4.0	38	4.7	3.3	0—12	4.0	49	4.3	3.31
reversals	2—5	0—10	5.0	35	4.9	2.66	1—15	5.0	38	5.8	3.7	0—13	5.0	49	4.9	3.55
C 1 → 0	2—6	0—11	5.0	35	5.4	2.66	1—16	5.5	38	6.3	4.1	0—17	5.0	49	5.3	3.95
Cumulative	2	—4— 9	0.5	33	0.5	2.82	—8— 6	0.0	38	0.4	2.6	— 8— 4	0.0	49	0.2	2.15
net	2—3	—4—13	0.5	35	1.6	3.80	—6—10	0.0	38	0.6	3.2	—12— 7	0.0	49	0.0	3.44
increment	2—4	—4—17	1.5	35	2.5	4.95	—6—10	1.0	38	0.9	3.8	—12—15	0.0	49	—0.0	4.24
0 ⇌ C 1	2—5	—4—18	1.5	35	3.0	5.42	—6—10	0.5	38	1.1	3.6	—12—12	0.0	49	—0.3	4.05
	2—6	—3—19	2.5	35	4.2	5.71	—5—16	2.5	38	2.4	4.5	—12—13	0.0	49	0.0	4.53

Table IV. *Development of primary carious lesions without defect. Clinical and additional radiographic C 1- and CR 1-type reversals, and net increment*

		Sucrose					Fructose					Xylitol				
	Term	R_s	Md	N	$\bar{x}$	S.D.$_s$	R_f	Md	N	$\bar{x}$	S.D.$_f$	R_x	Md	N	$\bar{x}$	S.D.$_x$
Cumulative	2—3	1—16	5.0	35	5.4	3.39	0—12	5.0	38	5.2	3.7	0—12	3.0	49	4.0	2.92
positive reversals	2—5	1—26	9.0	35	9.7	6.19	0—18	8.0	38	8.6	5.5	1—18	5.0	49	6.2	3.94
0→(C 1+CR 1)	2—6	2—29	10.0	35	12.1	7.16	1—24	10.5	38	11.0	6.9	1—21	7.0	49	7.6	4.21
Cumulative	2—3	0— 8	3.5	35	3.9	2.30	0—12	4.0	38	4.6	3.1	0—12	4.0	49	4.4	2.77
negative reversals	2—5	1—12	6.0	35	6.4	2.80	1—16	6.5	38	7.2	3.9	0—16	6.0	49	6.8	3.84
(C 1+CR 1)→0	2—6	2—14	7.5	35	7.4	3.13	2—17	8.0	38	8.4	4.6	0—19	7.5	49	7.9	4.18
Cumulative	2	—4— 9	0.0	35	0.1	2.64	—9— 6	0.0	38	0.3	2.7	— 8— 4	0.0	49	—0.2	2.23
net increment	2—3	—3—12	1.0	35	1.5	3.69	—7— 8	0.0	38	0.6	3.4	—12— 8	—1.0	49	—0.4	3.82
0⇌(C 1+CR 1)	2—5	—5—17	2.0	35	3.3	5.50	—6— 9	1.0	38	1.3	3.9	—10—12	0.0	49	—0.6	4.44
	2—6	—3—18	3.0	35	4.7	6.14	—6—14	2.0	38	2.6	4.7	—12—14	0.0	49	—0.4	4.88

Table V. *Development of primary carious lesions with defect. Clinical C 2-type reversals and net increment*

		Sucrose				Fructose				Xylitol			
	Term	R_s	Md	N	$\bar{x}$ S.D.$_s$	R_f	Md	N	$\bar{x}$ S.D.$_f$	R_x	Md	N	$\bar{x}$ S.D.$_x$
	2	0—0	0.0	33	0.0 0.0	0—2	0.0	38	0.2 0.4	0—2	0.0	49	0.1 0.40
Positive	3	0—1	0.0	35	0.1 0.36	0—2	0.0	38	0.2 0.5	0—1	0.0	49	0.1 0.30
reversals	4	0—1	0.0	35	0.0 0.17	0—1	0.0	38	0.1 0.3	0—2	0.0	49	0.0 0.28
0 → C 2	5	0—1	0.0	35	0.1 0.29	0—1	0.0	38	0.1 0.3	0—0	0.0	49	0.0 0.0
	6	0—1	0.0	35	0.2 0.43	0—3	0.0	38	0.2 0.6	0—1	0.0	49	0.1 0.24
	2	0—1	0.0	33	0.0 0.18	0—0	0.0	38	0.0 0.0	0—3	0.0	49	0.1 0.51
Negative	3	0—1	0.0	35	0.0 0.17	0—1	0.0	38	0.0 0.2	0—1	0.0	49	0.0 0.20
reversals	4	0—0	0.0	35	0.0 0.0	0—0	0.0	38	0.0 0.0	0—1	0.0	49	0.0 0.14
C 2 → 0	5	0—1	0.0	35	0.0 0.17	0—0	0.0	38	0.0 0.0	0—0	0.0	49	0.0 0.0
	6	0—0	0.0	35	0.0 0.0	0—0	0.0	38	0.0 0.0	0—1	0.0	49	0.0 0.14
Cumulative	2—3	0—1	0.0	35	0.1 0.36	0—3	0.0	38	0.3 0.7	0—2	0.0	49	0.2 0.48
positive	2—4	0—2	0.0	35	0.2 0.46	0—4	0.0	38	0.4 0.9	0—2	0.0	49	0.3 0.54
reversals	2—5	0—3	0.0	35	0.3 0.62	0—4	0.0	38	0.5 1.0	0—2	0.0	49	0.3 0.54
C 2 → 0	2—6	0—4	0.0	35	0.5 0.79	0—5	0.0	38	0.8 1.1	0—2	0.0	49	0.3 0.59
Cumulative	2—3	0—1	0.0	35	0.1 0.24	0—1	0.0	38	0.0 0.2	0—3	0.0	49	0.1 0.53
negative	2—4	0—1	0.0	35	0.1 0.24	0—1	0.0	38	0.0 0.2	0—3	0.0	49	0.2 0.55
reversals	2—5	0—1	0.0	35	0.1 0.29	0—1	0.0	38	0.0 0.2	0—3	0.0	49	0.2 0.55
C 2→0	2—6	0—1	0.0	35	0.1 0.29	0—1	0.0	38	0.0 0.2	0—3	0.0	49	0.2 0.63
	2	—1—0	0.0	33	—0.0 0.18	0—2	0.0	38	0.2 0.4	—3—2	0.0	49	0.0 0.67
Cumulative	2—3	—1—1	0.0	35	0.1 0.45	0—2	0.0	38	0.3 0.6	—2—1	0.0	49	0.1 0.61
net increment	2—4	—1—2	0.0	35	0.1 0.54	0—3	0.0	38	0.4 0.8	—2—2	0.0	49	0.1 0.69
0⇌C 2	2—5	—1—3	0.0	35	0.2 0.67	0—3	0.0	38	0.5 0.9	—2—2	0.0	49	0.1 0.69
	2—6	—1—4	0.0	35	0.4 0.86	0—4	0.0	38	0.7 1.0	—3—2	0.0	49	0.2 0.82

Table VI. *Development of primary carious lesions with defect. Clinical and additional radiographic C 2- and CR 2-type reversals, and net increment*

		Sucrose				Fructose				Xylitol			
	Term	R_s	Md	N	$\bar{x}$ S.D.$_s$	R_f	Md	N	$\bar{x}$ S.D.$_f$	R_x	Md	N	$\bar{x}$ S.D.$_x$
Cumulative	2—3	0—1	0.0	35	0.2 0.39	0—5	0.0	38	0.5 1.0	0—3	0.0	49	0.5 0.71
positive reversals	2—5	0—3	0.0	35	0.4 0.65	0—6	0.0	38	0.8 1.3	0—3	0.0	49	0.6 0.79
0→(C 2+CR 2)	2—6	0—4	1.0	35	0.8 1.07	0—7	1.0	38	1.2 1.6	0—4	0.0	49	0.7 0.98
Cumulative	2—3	0—1	0.0	35	0.1 0.24	0—1	0.0	38	0.1 0.3	0—3	0.0	49	0.2 0.56
negative reversals	2—5	0—2	0.0	35	0.2 0.46	0—1	0.0	38	0.2 0.4	0—3	0.0	49	0.3 0.68
(C 2+CR 2)→0	2—6	0—2	0.0	35	0.2 0.46	0—1	0.0	38	0.2 0.4	0—4	0.0	49	0.4 0.83
Cumulative	2	—1—0	0.0	33	—0.0 0.18	—1—2	0.0	38	0.1 0.5	—3—2	0.0	49	0.0 0.67
net increment	2—3	—1—1	0.0	35	0.1 0.48	—1—4	0.0	38	0.4 0.9	—2—2	0.0	49	0.3 0.76
0→(C 2+CR 2)	2—5	—1—3	0.0	35	0.2 0.80	—1—5	0.0	38	0.6 1.1	—2—2	0.0	49	0.2 0.80
	2—6	—1—4	0.5	35	0.6 0.99	0—6	0.5	38	0.9 1.3	—4—3	0.0	49	0.3 1.07

Table VII. *Increase in size of clinical primary caries reversals. C 1 ⇌ C 2-type development and net increment*

		Sucrose				Fructose				Xylitol			
	Term	R_s	Md	N	$\bar{x}$ S.D.$_s$	R_f	Md	N	$\bar{x}$ S.D.$_f$	R_x	Md	N	$\bar{x}$ D.S.$_x$
	2	0—1	0.0	33	0.1 0.25	0—2	0.0	38	0.2 0.6	0—1	0.0	49	0.1 0.33
Positive	3	0—1	0.0	35	0.0 0.17	0—1	0.0	38	0.2 0.4	0—1	0.0	49	0.2 0.37
reversals	4	0—2	0.0	34	0.2 0.44	0—1	0.0	38	0.1 0.2	0—1	0.0	49	0.1 0.27
C 1 → C 2	5	0—2	0.0	35	0.4 0.70	0—3	0.0	38	0.4 0.8	0—1	0.0	49	0.1 0.24
	6	0—4	0.0	35	0.8 1.09	0—5	0.0	38	0.6 1.0	0—2	0.0	49	0.2 0.49
	2	0—0	0.0	33	0.0 0.0	0—2	0.0	38	0.1 0.3	0—6	0.0	49	0.1 0.86
Negative	3	0—1	0.0	35	0.0 0.17	0—2	0.0	38	0.1 0.4	0—2	0.0	49	0.1 0.36
reversals	4	0—1	0.0	34	0.0 0.17	0—3	0.0	38	0.1 0.5	0—2	0.0	49	0.1 0.36
C 2 → C 1	5	0—0	0.0	35	0.0 0.0	0—1	0.0	38	0.1 0.3	0—1	0.0	49	0.1 0.24
	6	0—2	0.0	35	0.1 0.38	0—0	0.0	38	0.0 0.0	0—1	0.0	49	0.0 0.14
Cumulative	2—3	0—1	0.0	35	0.1 0.29	0—3	0.0	38	0.4 0.8	0—2	0.0	49	0.3 0.50
positive reversals	2—4	0—2	0.0	35	0.2 0.50	0—4	0.0	38	0.4 0.9	0—2	0.0	49	0.4 0.56
C 1 → C 2	2—5	0—4	0.0	35	0.6 1.01	0—4	0.0	38	0.8 1.3	0—2	0.0	49	0.4 0.61
	2—6	0—8	1.0	35	1.4 1.88	0—6	1.0	38	1.4 1.8	0—3	0.0	49	0.6 0.78
Cumulative	2—3	0—1	0.0	35	0.0 0.17	0—3	0.0	38	0.2 0.6	0—7	0.0	49	0.2 1.04
negative	2—4	0—1	0.0	35	0.1 0.24	0—4	0.0	38	0.3 0.9	0—7	0.0	49	0.3 1.08
reversals	2—5	0—1	0.0	35	0.1 0.24	0—5	0.0	38	0.3 1.1	0—7	0.0	49	0.4 1.11
C 2 → C 1	2—6	0—2	0.0	35	0.1 0.50	0—5	0.0	38	0.3 1.1	0—7	0.0	49	0.4 1.11
Cumulative	2	0—1	0.0	33	0.1 0.25	0—2	0.0	38	0.2 0.5	—6—1	0.0	49	—0.0 0.94
net	2—3	—1—1	0.0	35	0.1 0.34	—1—3	0.0	38	0.2 0.7	—7—2	0.0	49	0.0 1.16
increment	2—4	—1—2	0.0	35	0.2 0.58	—3—4	0.0	38	0.2 1.0	—7—2	0.0	49	0.0 1.17
C 1 ⇌ C 2	2—5	0—4	0.0	35	0.6 0.99	—1—4	0.0	38	0.5 1.1	—7—2	0.0	49	0.0 1.17
	2—6	0—8	1.0	35	1.3 1.77	—1—6	0.5	38	1.1 1.6	—7—2	0.0	49	0.2 1.29

Table VIII. *Increase in size of clinical and radiographical primary caries reversals. C 1 ⇌ C 2- and CR 1 ⇌ CR 2-type development and net increment*

		Sucrose				Fructose				Xylitol			
	Term	R_s	Md	N	$\bar{x}$ S.D.$_s$	R_f	Md	N	$\bar{x}$ S.D.$_f$	R_x	Md	N	$\bar{x}$ S.D.$_x$
Cumulative	2—3	0— 2	0.0	35	0.3 0.51	0—3	0.0	38	0.6 0.9	0—4	0.0	49	0.6 0.83
positive	2—5	0— 6	1.0	35	1.1 1.37	0—6	1.0	38	1.3 1.5	0—5	1.0	49	1.1 1.24
reversals	2—6	0—10	1.0	35	2.1 2.39	0—8	2.0	38	2.1 2.1	0—5	1.0	49	1.4 1.43
Cumulative	2—3	0— 2	0.0	35	0.2 0.55	0—3	0.0	38	0.4 0.8	0—7	0.0	49	0.4 1.12
negative	2—5	0— 2	0.0	35	0.3 0.57	0—6	0.0	38	0.6 1.3	0—7	0.0	49	0.6 1.31
reversals	2—6	0— 3	0.0	35	0.4 0.78	0—6	0.0	38	0.7 1.4	0—7	0.0	49	0.9 1.51
Cumulative	2	—1— 1	0.0	33	—0.0 0.40	—1—2	0.0	38	0.2 0.7	—5—1	0.0	49	0.0 0.89
net increment	2—3	—2— 2	0.0	35	0.0 0.76	—2—3	0.0	38	0.2 1.0	—6—3	0.0	49	0.2 1.30
C 1 ⇌ C 2	2—5	—1— 4	1.0	35	0.9 1.04	—2—6	0.0	38	0.7 1.6	—5—3	0.0	49	0.5 1.31
CR 1 ⇌ CR 2	2—6	0— 8	1.0	35	1.7 1.82	—2—7	1.0	38	1.3 1.9	—4—3	0.0	49	0.4 1.30

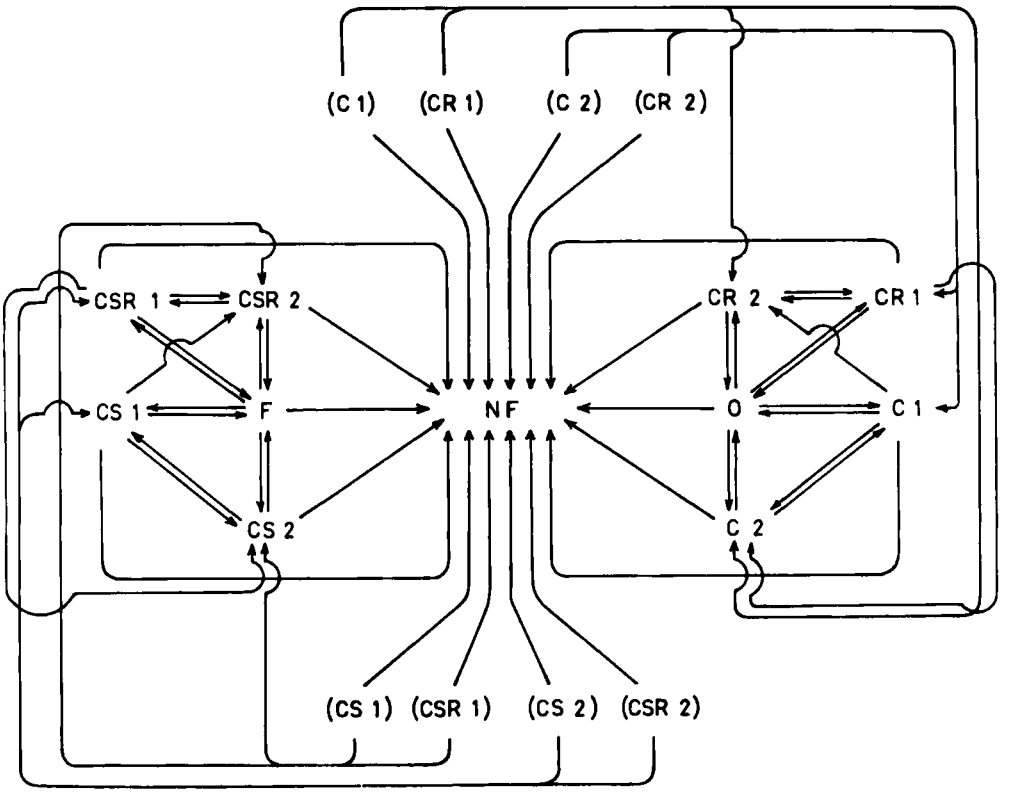

Fig. 2. Development of clinical and radiographic caries reversals. The occurrence of positive and negative reversals is indicated through arrows. The scheme is incomplete regarding development of baseline lesions (in brackets).

0 = intact tooth surface
C = clinical caries reversal
CR = radiographical caries reversal
CS = secondary caries reversal
CSR = radiographical secondary caries reversal
1 = lesion without defect
2 = lesion with defect
F = filled surface (at baseline examination)
NF = new filled surface
( ) = prestudy carious lesions (at baseline examination)

were taken using the method described by *Backer Dirks, van Amerongen & Winkler* (1951). This method standardizes the angulation of the central ray and target film distance by a special apparatus. In order to reduce the dose the apparatus was modified by collimating the beam to correspond to the size and form of the film.

The test persons were radiographed four times during the first year of the trial. General Electric model 11CE 2—2 X-ray apparatus was used at 90 kV and 15 mA. The high voltage was used to further minimize the dose. The films were developed under standardized conditions and read at 1.5 × magnification in adjustable light.

The condition of the distal surface of the canine and mesial and distal surfaces of the premolars and molars was recorded from the radiographs. A radiographic lesion was recorded as incipient caries (CR 1 or CSR 1) when there was a radiolucent area involving a part of enamel. An advanced lesion (CR 2 or CSR 2) was

recorded when a radiolucent area involved whole enamel up to amelodentinal junction or involved also dentin.

Evaluation of clinical and radiographic findings. The parameters at the clinical (C 1, C 2, CS 1, CS 2, F) and radiographic (CR 1, CR 2, CSR 1, CSR 2) registrations were utilized as a basis for calculating the reversals in diagnosis between the examinations, and the resulting net change. The positive reversals involved a change in diagnosis from an intact surface (0) to C 1 or C 2, or when considering separately the increment in lesion size, from C 1 to C 2. A negative reversal indicated a corresponding change in the opposite direction. Consequently, the net increment was expressed as new carious surfaces (positive reversals) minus negative reversals (COCSTOC, 1973). The various possibilities for the occurrence of positive and negative clinical and radiographic reversals are schematically indicated in a diagram (Fig. 2), which should be considered also with regard to changes in the condition of prestudy lesions. These parameters for the clinical and additional radiographic findings, were calculated separately for all (28) teeth excluding the wisdom teeth, and the (4) wisdom teeth, and formed the essential basis for establishing the caries increment during the study. The present intermediate report deals, however, with the findings covering all other, except the wisdom teeth.

The total caries incidence was calculated on the basis of the net increment of carious surfaces as defined above, part of these surfaces being replaced by new fillings. In addition, the new fillings at clinically and radiographically intact surfaces, and the number of missed tooth surfaces, calculated as four surfaces per tooth extracted due to caries were included in the calculations. The overall caries activity was expressed in additional ways, taking into account both the quantitative and qualitative changes. These combined indices will be separately given in combination with the presentation of the results.

As mentioned above, part of the new C 1-, C 2-, CS 1- and CS 2-lesions was substituted by fillings. This happened scarcely, and tables showing the changes from positive caries reversals to filled surfaces have for this reason not been included. On the other hand, all these filled surfaces were considered as carious, and not calculated as negative reversals. The new fillings appearing at surfaces found a) carious at the baseline examination, b) carious during the study, and c) clinically and radiographically intact, were reported for separately by considering these three main classes of entry. A detailed analysis of all subclasses (Fig. 2) reveals 18 independent ways of entry of new fillings. Due to an anticipated low number of new fillings, the subgroups were combined and only the above three main categories considered.

Sucrose-, fructose- and xylitol-containing products. In order to enhance the cooperation of the participants a variety of sugar products were developed solely for use of the test persons during the study. The total assortment comprised about 100 products containing the specific sugars used in the trial. The following products were thus included.

1. Sucrose, fructose and xylitol as a sweetener in coffee, tea, soft drinks, juices, soup, porridges, jams and marmelade
2. As a constituent in pastry (about 30 products in each sugar group)
3. As a constituent in sweets (chocolate, bonbons, dragées, chewing-gum)
4. As a constituent in various high-sugar containing products (marinated

Table IX. *Development of secondary carious lesions without defect. Clinical CS 1-type reversals and net increment*

		Sucrose					Fructose					Xylitol				
	Term	R_s	Md	N	$\bar{x}$	S.D.$_s$	R_f	Md	N	$\bar{x}$	S.D.$_f$	R_x	Md	N	$\bar{x}$	S.D.$_x$
	2	0—2	0.0	33	0.3	0.58	0—2	0.0	38	0.4	0.6	0—3	0.0	49	0.3	0.63
Positive	3	0—3	0.0	35	0.6	0.89	0—3	0.0	38	0.6	0.9	0—4	0.0	49	0.7	0.89
reversals	4	0—2	0.0	34	0.3	0.59	0—2	0.0	38	0.4	0.6	0—3	0.0	49	0.4	0.66
F → CS 1	5	0—3	0.0	35	0.6	0.82	0—3	0.0	38	0.4	0.8	0—2	0.0	49	0.2	0.51
	6	0—5	0.0	35	0.6	1.02	0—2	0.0	38	0.3	0.6	0—5	0.0	49	0.5	0.97
	2	0—2	0.0	33	0.2	0.45	0—5	0.0	38	0.2	0.9	0—2	0.0	49	0.2	0.49
Negative	3	0—2	0.0	35	0.2	0.61	0—2	0.0	38	0.1	0.4	0—2	0.0	49	0.1	0.39
reversals	4	0—2	0.0	34	0.2	0.55	0—3	0.0	38	0.4	0.7	0—3	0.0	49	0.4	0.69
CS 1 → F	5	0—1	0.0	35	0.1	0.24	0—3	0.0	38	0.2	0.6	0—2	0.0	49	0.4	0.60
	6	0—1	0.0	35	0.1	0.24	0—2	0.0	38	0.1	0.4	0—3	0.0	49	0.2	0.58
Cumulative	2—3	0—5	0.5	35	0.8	1.11	0—4	1.0	38	1.0	1.1	0—4	0.5	49	0.9	1.24
positive	2—4	0—6	1.0	35	1.1	1.39	0—5	1.0	38	1.4	1.3	0—5	1.0	49	1.3	1.43
reversals	2—5	0—7	2.0	35	1.7	1.61	0—5	2.0	38	1.7	1.4	0—7	1.0	49	1.5	1.73
F → CS 1	2—6	0—9	2.0	35	2.3	2.10	0—5	2.0	38	2.0	1.6	0—9	2.0	49	2.0	2.05
Cumulative	2—3	0—3	0.0	35	0.4	0.85	0—5	0.0	38	0.3	0.9	0—3	0.0	49	0.3	0.71
negative	2—4	0—5	0.0	35	0.6	1.10	0—6	0.0	38	0.7	1.3	0—4	0.0	49	0.7	1.00
reversals	2—5	0—6	0.0	35	0.6	1.23	0—6	0.0	38	0.9	1.4	0—5	1.0	49	1.0	1.21
CS 1 → F	2—6	0—7	0.0	35	0.7	1.43	0—7	0.0	38	1.0	1.5	0—8	1.0	49	1.2	1.47
	2	—2—2	0.0	33	0.1	0.71	—5—2	0.0	38	0.1	1.2	—2—3	0.0	49	0.1	0.74
Cumulative	2—3	—3—3	0.0	35	0.4	1.21	—3—3	0.0	38	0.7	1.1	—2—4	0.0	49	0.6	1.21
net increment	2—4	—3—3	0.0	35	0.5	1.28	—4—3	0.0	38	0.7	1.3	—3—3	0.0	49	0.6	1.23
F ⇌ CS 1	2—5	—2—4	1.0	35	1.0	1.45	—4—5	1.0	38	0.8	1.4	—3—5	0.0	49	0.5	1.37
	2—6	—2—8	2.0	35	1.6	1.92	—5—5	1.0	38	1.0	1.6	—4—8	0.0	49	0.8	1.90

Table X. *Development of secondary carious lesions without defect. Clinical and additional radiographic CS 1 and CSR 1-type reversals, and net increment*

		Sucrose					Fructose					Xylitol				
	Term	R_s	Md	N	$\bar{x}$	S.D.$_s$	R_f	Md	N	$\bar{x}$	S.D.$_f$	R_x	Md	N	$\bar{x}$	S.D.$_x$
Cumulative	2—3	0—5	0.5	35	0.9	1.13	0—4	1.0	38	1.1	1.1	0— 4	1.0	49	1.0	1.23
positive reversals	2—5	0—7	2.0	35	1.8	1.63	0—5	2.0	38	1.8	1.5	0— 8	1.0	49	1.6	1.84
F → (CS1+CSR1)	2—6	0—9	2.0	35	2.4	2.18	0—6	2.0	38	2.2	1.7	0—10	2.0	49	2.1	2.19
Cumulative	2—3	0—3	0.0	35	0.5	0.90	0—5	0.0	38	0.4	1.0	0— 3	0.0	49	0.4	0.78
negative reversals	2—5	0—6	0.0	35	0.8	1.23	0—6	1.0	38	1.1	1.4	0— 6	1.0	49	1.1	1.36
(CS1+CSR1) → F	2—6	0—7	0.0	35	0.9	1.44	0—7	1.0	38	1.2	1.5	0— 8	1.0	49	1.3	1.61
Cumulative	2	—2—2	0.0	33	0.1	0.73	—5—2	0.0	38	0.2	1.2	—2— 3	0.0	49	0.1	0.74
net	2—3	—3—3	0.0	35	0.4	1.20	—3—3	0.0	38	0.6	1.2	—2— 4	0.0	49	0.6	1.18
increment	2—5	—2—4	1.0	35	1.0	1.39	—4—5	1.0	38	0.8	1.5	—3— 5	0.0	49	0.5	1.52
F ⇌ (CS1+CSR1)	2—6	—2—9	2.0	35	1.6	2.00	—5—5	1.0	38	1.1	1.7	—4— 9	0.0	49	0.8	2.05

Table XI. *Development of secondary carious lesions with defect. Clinical CS 2-type reversals and net increment*

		Sucrose				Fructose				Xylitol			
	Term	R_s	Md	N	$\bar{x}$ S.D.$_s$	R_f	Md	N	$\bar{x}$ S.D.$_f$	R_x	Md	N	$\bar{x}$ S.D.$_x$
	2	0—0	0.0	33	0.0 0.0	0—1	0.0	38	0.0 0.2	0—2	0.0	49	0.2 0.48
Positive	3	0—4	0.0	35	0.2 0.74	0—3	0.0	38	0.2 0.6	0—1	0.0	49	0.1 0.24
reversals	4	0—1	0.0	34	0.1 0.29	0—2	0.0	38	0.2 0.4	0—1	0.0	49	0.0 0.14
F → CS 2	5	0—1	0.0	35	0.1 0.36	0—1	0.0	38	0.1 0.3	0—1	0.0	49	0.0 0.20
	6	0—5	0.0	35	0.3 0.90	0—2	0.0	38	0.3 0.7	0—2	0.0	49	0.1 0.31
	2	0—1	0.0	33	0.0 0.18	0—0	0.0	38	0.0 0.0	0—4	0.0	49	0.1 0.57
Negative	3	0—2	0.0	35	0.1 0.34	0—0	0.0	38	0.0 0.0	0—1	0.0	49	0.0 0.20
reversals	4	0—1	0.0	34	0.0 0.17	0—1	0.0	38	0.0 0.2	0—0	0.0	49	0.0 0.0
CS 2 → F	5	0—0	0.0	35	0.0 0.0	0—0	0.0	38	0.0 0.0	0—1	0.0	49	0.0 0.14
	6	0—0	0.0	35	0.0 0.0	0—0	0.0	38	0.0 0.0	0—0	0.0	49	0.0 0.0
Cumulative	2—3	0—4	0.0	35	0.2 0.74	0—3	0.0	38	0.2 0.6	0—3	0.0	49	0.3 0.65
positive	2—4	0—4	0.0	35	0.3 0.81	0—4	0.0	38	0.3 0.9	0—3	0.0	49	0.3 0.71
reversals	2—5	0—5	0.0	35	0.5 1.08	0—4	0.0	38	0.4 0.9	0—3	0.0	49	0.4 0.75
F → CS 2	2—6	0—8	0.0	35	0.7 1.71	0—4	0.0	38	0.7 1.1	0—5	0.0	49	0.4 0.95
Cumulative	2—3	0—2	0.0	35	0.1 0.38	0—0	0.0	38	0.0 0.0	0—5	0.0	49	0.1 0.72
negative	2—4	0—2	0.0	35	0.1 0.41	0—1	0.0	38	0.0 0.2	0—5	0.0	49	0.1 0.72
reversals	2—5	0—2	0.0	35	0.1 0.41	0—1	0.0	38	0.0 0.2	0—5	0.0	49	0.1 0.73
CS 2 → F	2—6	0—2	0.0	35	0.1 0.41	0—1	0.0	38	0.0 0.2	0—5	0.0	49	0.1 0.73
Cumulative	2	—1—0	0.0	33	—0.0 0.18	0—1	0.0	38	0.0 0.2	—2—1	0.0	49	0.2 0.51
net	2—3	—2—4	0.0	35	0.1 0.86	0—3	0.0	38	0.2 0.6	—2—2	0.0	49	0.2 0.56
increment	2—4	—2—4	0.0	35	0.2 0.91	0—3	0.0	38	0.3 0.8	—2—3	0.0	49	0.2 0.64
F ⇌ CS 2	2—5	—2—5	0.0	35	0.4 1.18	0—3	0.0	38	0.4 0.8	—2—2	0.0	49	0.2 0.62
	2—6	—2—8	0.0	35	0.6 1.79	0—3	0.0	38	0.7 1.0	0—2	0.0	49	0.3 0.57

Table XII. *Development of secondary carious lesions with defect. Clinical and additional radiographic CS 2 and CSR 2-type reversals, and net increment*

		Sucrose				Fructose				Xylitol			
	Term	R_s	Md	N	$\bar{x}$ S.D.$_s$	R_f	Md	N	$\bar{x}$ S.D.$_f$	R_x	Md	N	$\bar{x}$ S.D.$_x$
Cumulative	2—3	0— 4	0.0	35	0.3 0.75	0—3	0.0	38	0.2 0.6	0—3	0.0	49	0.3 0.72
positive reversals	2—5	0— 6	0.0	35	0.6 1.23	0—4	0.0	38	0.6 1.0	0—3	0.0	49	0.4 0.84
F → (CS2+CSR2)	2—6	0—11	0.0	35	1.0 2.21	0—4	0.5	38	1.0 1.2	0—5	0.0	49	0.5 1.05
Cumulative	2—3	0— 2	0.0	35	0.1 0.41	0—1	0.0	38	0.1 0.3	0—5	0.0	49	0.2 0.74
negative reversals	2—5	0— 2	0.0	35	0.2 0.46	0—2	0.0	38	0.2 0.5	0—5	0.0	49	0.2 0.77
(CS2+CSR2) → F	2—6	0— 2	0.0	35	0.3 0.58	0—2	0.0	38	0.2 0.5	0—5	0.0	49	0.2 0.77
Cumulative	2	—1— 0	0.0	33	—0.1 0.25	—1—1	0.0	38	0.0 0.2	—2—2	0.0	49	0.2 0.56
net	2—3	—2— 4	0.0	35	0.1 0.89	—1—3	0.0	38	0.2 0.6	—2—2	0.0	49	0.2 0.63
increment	2—5	—2— 6	0.0	35	0.4 1.31	—2—3	0.0	38	0.4 0.9	—2—3	0.0	49	0.2 0.69
F ⇌ (CS2+CSR2)	2—6	—2—10	0.0	35	0.7 2.21	0—3	0.0	38	0.8 1.0	0—3	0.0	49	0.3 0.71

Fig. 3. An assortment of xylitol-containing products used by the test persons. In the other sugar groups the products were of similar appearance and quality. Not all manufactured products are shown.

herring, cucumber jelly, pickles, mustard, cough mixture etc.).

A part of the xylitol-containing products is shown in Fig. 3.

Further studies belonging to the main project. A variety of associated investigations were initiated parallel to the main clinical and radiographic trial. These studies involved determinations on periodontal tissues, plaque, oral fluid, serum and urine, in order to observe eventual other accompanying differences on an individual level, and between the groups. The biochemical, microbiological, periodontal and general methodology will be reported for separately in forthcoming papers belonging to these series.

Statistical calculations. In view of the extremely skew distribution of the incidence of dental caries, the discontinuous nature of the caries indices, and the relatively small size of the groups, non-parametric procedures were preferred. The overall comparison of the differences was carried out by using the Kruskal-Wallis test, and the differences between the sugar groups tested for significance with the Mann-Whitney U-test (*Bradley*, 1968; *Chilton*, 1967).

RESULTS

During the first 12 months of selective sugar intake only one person in the X-group ceased from participation. The reason was diarrhoea, which appeared in a mild form in part of the test persons in the X-group in the beginning of the study but rapidly disappeared completely in most instances. In the case mentioned, the symptoms persisted until after some weeks mere thinking of the products caused the reaction. This participant was in fact replaced by another test person. In prolonged use, solid products, i.e. chocolate, candy, chewing-gum and pastry, were well tolerated. The intake of large amounts of xylitol-containing soft drinks resulted often in osmotic diarrhoea of short duration. It should be noted, however, that in a majority of cases no side-effects appeared. In the two other sugar groups no adverse effects were reported.

In the subsequent calculations 2 further test persons from the X-group were excluded, due to lack of maintenance of diet and nonattendance of part of the registrations.

As mentioned in »Material and

methods», no significant differences were initially found between the sugar groups. The baseline values, covering the initial material, less the 3 participants in the X-group, is presented in Table II.

During the first year of the study a total of six series of clinical registrations and four series of radiographical surveys of dental caries were carried out. The reasons for the relative large number of these inspections will be given in the discussion. These registrations were evenly spaced during the year (Figs. 4—5), except the 2nd and 4th clinical inspections which were carried out immediately after the preceding series and served as duplicate determinations for establishing the method error.

The clinical and radiographic findings during the first year of intake of the selective sugars are presented with regard to the separate parameters and the combined caries indices of the various groups. The results are given in a number of subsequent tables and figures, the former yielding information about the positive and negative reversals and their difference, the net increment at the various registrations. In addition, the corresponding cumulative values, indicating the total change during the study, are also given. The tables further include information about the range, median, number of observations, mean and standard deviation of the experimental variable.

Primary caries

C 1-lesions. The development of clinically detected new C 1-lesions from intact tooth surfaces appears in Table III and Fig. 4 a. After one year of the selective diets there were thus 9.6 new carious surfaces (positive reversals) in the S-group, the corresponding values being 8.7 in the F-group, and 5.3 in the X-group. The disappearance rate (negative reversals) was 5.4 surfaces in the S-group, 6.3 in the F-group, and 5.3 in the X-group. After one year the net increment rate of the clinically detected C 1-lesions was thus 4.2 in the S-group, 2.4 in the F-group, and 0.0 in the X-group. The difference between the groups was highly significant with regard to the X- and S-groups ($P \leq 0.005$), and significant between the X- and F-groups ($P \leq 0.05$). The difference between the F- and S-groups was not significant. The significance levels for the variables are separately shown in Table XXV.

The development of clinically and additional radiographically detected C 1-reversals appears similarly in Table IV and Fig. 4 b, the significance level for the differences between the cumulative net increment in the three groups appearing in Table XXV.

C 2-lesions. The development of C 2-lesions from intact tooth surfaces in the short interval between two series of registrations was rare. The clinically detected positive and negative reversals at the inspections (Table V), the corresponding cumulative values and the net increment (Table V, Fig. 4 c) remained low due to the sporadic occurrence of these lesions.

The calculations involving the clinical and additional radiographic findings within this category (Table VI, Fig. 4 d) showed similar results, the differences in the net increment between the groups being not significant (Table XXV).

Development from C 1- to C 2-lesions. The development in the size of the lesions is shown separately for clinically detected (Table VII) and clinically and radiographically detected lesions (Table VIII).

Table XIII. *Increase in size of clinical secondary carious lesions. CS 1 ⇌ CS 2-type development and net increment*

		Sucrose					Fructose					Xylitol				
	Term	R_s	Md	N	$\bar{x}$	S.D.$_s$	R_f	Md	N	$\bar{x}$	S.D.$_f$	R_x	Md	N	$\bar{x}$	S.D.$_x$
	2	0—2	0.0	33	0.1	0.39	0—1	0.0	38	0.1	0.2	0—1	0.0	49	0.2	0.37
Positive	3	0—0	0.0	35	0.0	0.0	0—1	0.0	38	0.1	0.3	0—1	0.0	49	0.0	0.20
reversals	4	0—0	0.0	34	0.0	0.0	0—1	0.0	38	0.1	0.3	0—1	0.0	49	0.0	0.14
CS 1 → CS 2	5	0—1	0.0	35	0.1	0.29	0—1	0.0	38	0.1	0.3	0—2	0.0	49	0.2	0.42
	6	0—1	0.0	35	0.1	0.36	0—3	0.0	38	0.3	0.6	0—1	0.0	49	0.0	0.14
	2	0—1	0.0	33	0.1	0.30	0—1	0.0	38	0.0	0.2	0—1	0.0	49	0.1	0.24
Negative	3	0—0	0.0	35	0.0	0.0	0—1	0.0	38	0.0	0.2	0—1	0.0	49	0.0	0.20
reversals	4	0—0	0.0	34	0.0	0.0	0—2	0.0	38	0.1	0.3	0—0	0.0	49	0.0	0.0
CS 2 → CS 1	5	0—0	0.0	35	0.0	0.0	0—1	0.0	38	0.1	0.3	0—0	0.0	49	0.0	0.0
	6	0—1	0.0	35	0.1	0.24	0—1	0.0	38	0.0	0.2	0—1	0.0	49	0.0	0.14
Cumulative	2—3	0—2	0.0	35	0.1	0.38	0—1	0.0	38	0.2	0.4	0—2	0.0	49	0.2	0.45
positive	2—4	0—2	0.0	35	0.1	0.38	0—2	0.0	38	0.2	0.5	0—2	0.0	49	0.2	0.46
reversals	2—5	0—2	0.0	35	0.2	0.46	0—2	0.0	38	0.3	0.6	0—3	0.0	49	0.4	0.70
CS 1 → CS 2	2—6	0—2	0.0	35	0.3	0.53	0—3	0.0	38	0.6	0.9	0—3	0.0	49	0.4	0.70
Cumulative	2—3	0—1	0.0	35	0.1	0.29	0—1	0.0	38	0.1	0.2	0—1	0.0	49	0.1	0.30
negative	2—4	0—1	0.0	35	0.1	0.29	0—2	0.0	38	0.1	0.4	0—1	0.0	49	0.1	0.30
reversals	2—5	0—1	0.0	35	0.1	0.29	0—2	0.0	38	0.2	0.5	0—1	0.0	49	0.1	0.30
CS 2 → CS 1	2—6	0—1	0.0	35	0.1	0.36	0—2	0.0	38	0.2	0.5	0—2	0.0	49	0.1	0.39
Cumulative	2	—1—2	0.0	33	0.0	0.51	—1—1	0.0	38	0.0	0.3	—1—1	0.0	49	0.1	0.46
net	2—3	—1—2	0.0	35	0.0	0.49	—1—1	0.0	38	0.1	0.4	—1—2	0.0	49	0.1	0.54
increment	2—4	—1—2	0.0	35	0.0	0.49	—2—2	0.0	38	0.1	0.6	—1—2	0.0	49	0.1	0.52
CS 1 ⇌ CS 2	2—5	—1—2	0.0	35	0.1	0.51	—2—2	0.0	38	0.1	0.7	—1—3	0.0	49	0.3	0.67
	2—6	—1—2	0.0	35	0.2	0.67	—2—3	0.0	38	0.4	1.1	—1—3	0.0	49	0.3	0.70

Table XIV. *Increase in size of clinical and radiographical secondary carious lesions. CS 1 ⇌ CS 2 and CSR 1 ⇌ CSR 2-type development and net increment*

		Sucrose					Fructose					Xylitol				
	Term	R_s	Md	N	$\bar{x}$	S.D.$_s$	R_f	Md	N	$\bar{x}$	S.D.$_f$	R_x	Md	N	$\bar{x}$	D.S.$_x$
Cumulative	2—3	0—2	0.0	35	0.1	0.41	0—1	0.0	38	0.2	0.4	0—2	0.0	49	0.2	0.48
positive	2—5	0—2	0.0	35	0.2	0.48	0—2	0.0	38	0.3	0.6	0—3	0.0	49	0.4	0.70
reversals	2—6	0—2	0.0	35	0.4	0.54	0—3	0.0	38	0.6	1.0	0—3	0.0	49	0.4	0.70
Cumulative	2—3	0—1	0.0	35	0.1	0.29	0—1	0.0	38	0.1	0.3	0—1	0.0	49	0.1	0.30
negative	2—5	0—1	0.0	35	0.1	0.29	0—2	0.0	38	0.3	0.6	0—1	0.0	49	0.1	0.30
reversals	2—6	0—1	0.0	35	0.1	0.36	0—2	0.0	38	0.3	0.6	0—2	0.0	49	0.1	0.39
Cumulative	2	—1—2	0.0	33	0.0	0.51	—1—1	0.0	38	0.0	0.4	—1—1	0.0	49	0.1	0.48
net increment	2—3	—1—2	0.0	35	0.0	0.52	—1—1	0.0	38	0.1	0.5	—1—2	0.0	49	0.1	0.57
CS 1 ⇌ CS 2	2—5	—1—2	0.0	35	0.1	0.54	—2—2	0.0	38	0.1	0.9	—1—3	0.0	49	0.3	0.68
CSR 1 ⇌ CSR 2	2—6	—1—2	0.0	35	0.2	0.69	—2—3	0.0	38	0.3	1.1	—1—3	0.0	49	0.3	0.71

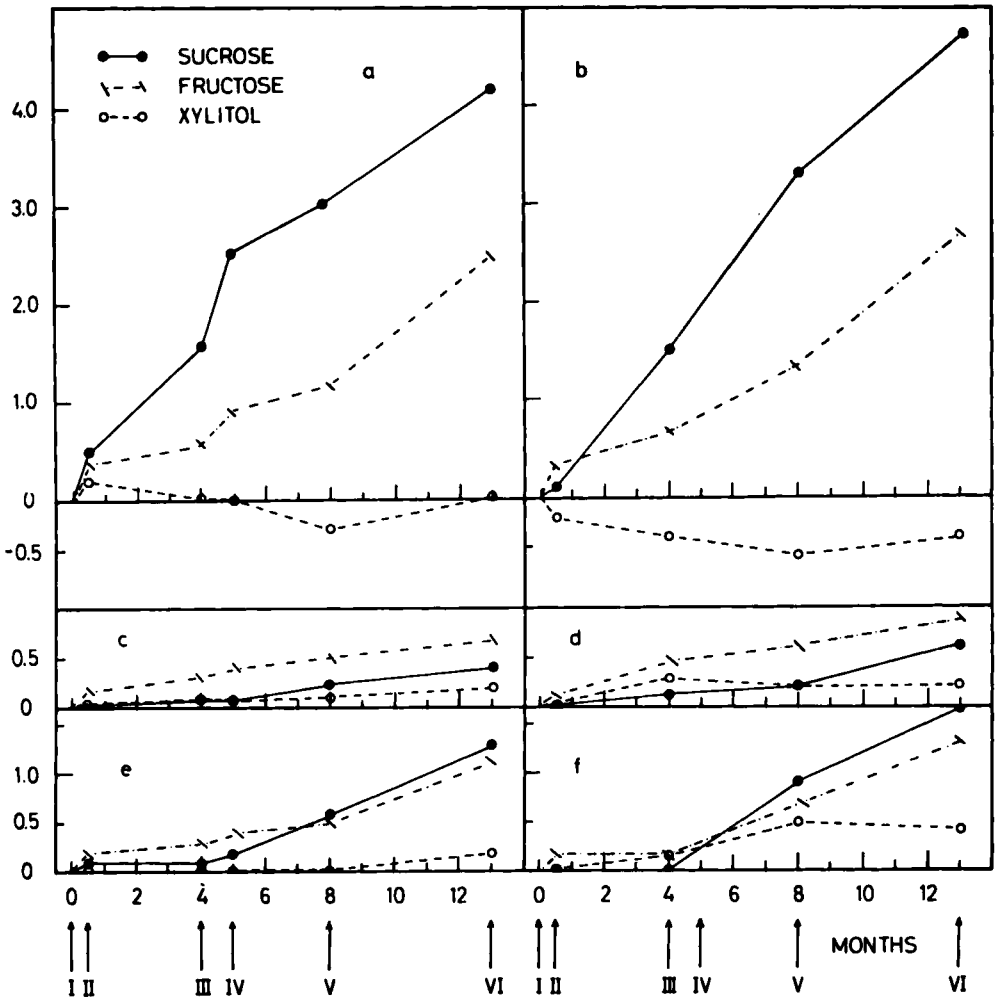

Fig. 4. Cumulative net increment of primary caries reversals,
a. Clinical lesions without defect, 0⇌C 1
b. Clinical and radiographical lesions without defect, 0⇌(C 1 + CR 1)
c. Clinical lesions with defect, 0⇌C 2
d. Clinical and radiographical lesions with defect, 0⇌(C 2 + CR 2)
e. Increase in size of clinical lesions, C 1⇌C 2
f. Increase in size of clinical and radiographical lesions, (C 1 + CR 1)⇌(C 2 + CR 2)

Changes from a C 1-type to a C 2-type occurred more frequently than direct development from intact to a C 2-lesion, the net increment consequently being moderately high (Table VII, VIII, Fig. 4 e, f). The differences between the X- and S-groups were highly significant, and between the X- and F-groups significant or almost significant (Table XXV). The differences between the F- and S-groups were not found significant.

Secondary caries

The development of secondary caries from previously filled tooth surfaces was handled in analogy with primary carious surfaces.

CS 1-lesions. The findings are shown in Table IX and X, and Fig. 5 a, b.

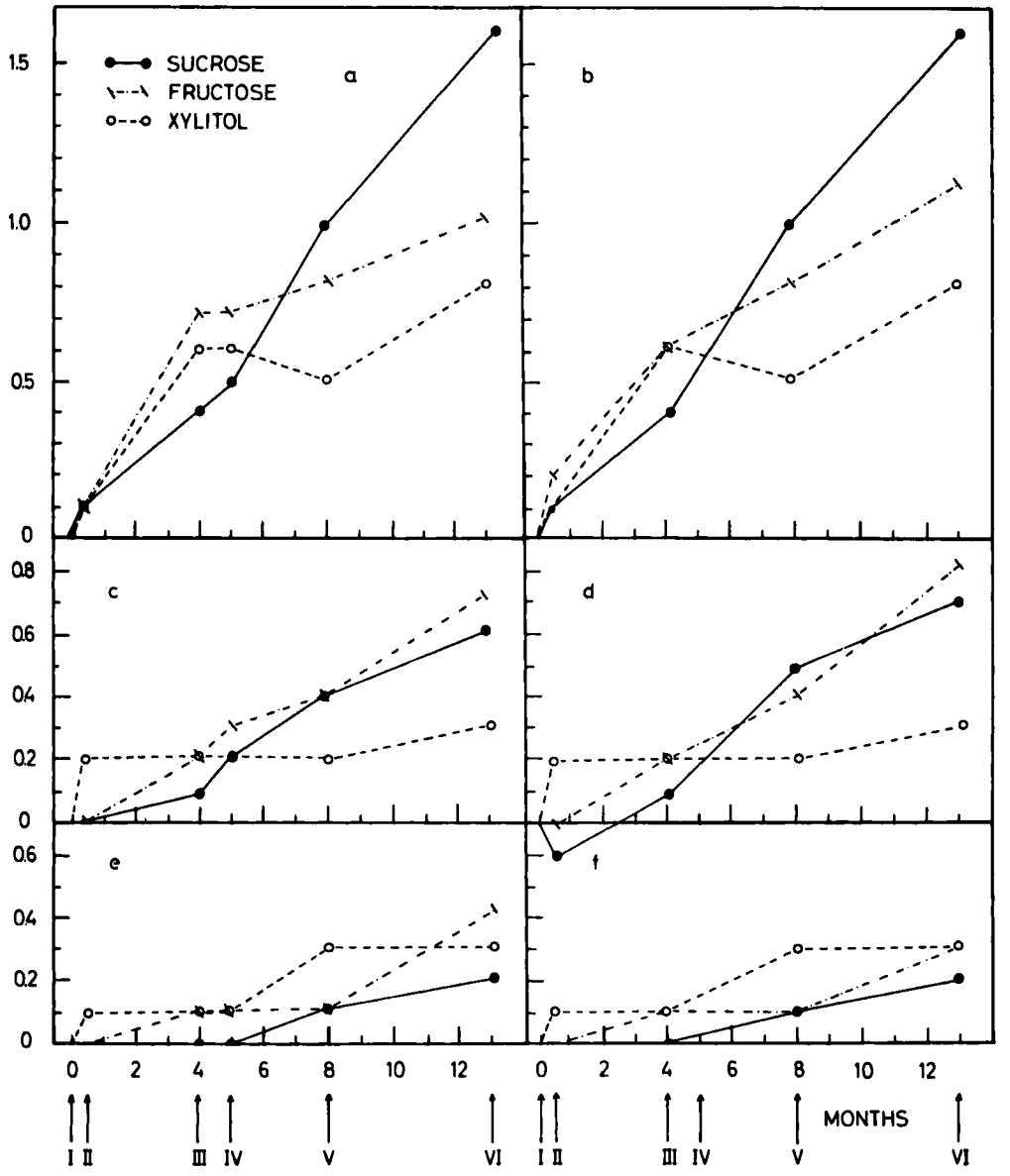

Fig. 5. Cumulative net increment of secondary caries reversals,
a. Clinical lesions without defect, F⇌CS 1
b. Clinical and radiographical lesions without defect, F⇌(CS 1 + CSR 1)
c. Clinical lesions with defect, F⇌CS 2
d. Clinical and radiographical lesions with defect, F⇌(CS 2 + CSR 2)
e. Increase in size of clinical lesions, CS 1⇌CS 2
f. Increase in size of clinical and radiographical lesions, (CS 1 + CSR 1)⇌(CS 2 + CSR 2)

Table XV. *Development of new filled surfaces with regard to total number of new fillings, substitution of caries reversals and intact tooth surfaces*

		Sucrose					Fructose					Xylitol				
New filled surfaces	Term	R_s	Md	N	$\bar{x}$	S.D.$_s$	R_f	Md	N	$\bar{x}$	S.D.$_f$	R_x	Md	N	$\bar{x}$	S.D.$_x$
Substitution of	1—2	0— 4	0	35	0.12	0.69	0— 1	0	38	0.05	0.23	0— 0	0	49	0.00	0.00
baseline lesions,	2—3	0— 6	0	35	0.38	1.23	0—14	0	38	1.47	2.73	0—18	0	49	1.32	3.02
caries increment	3—5	0—10	0	35	0.85	2.20	0—11	0	38	0.63	2.05	0—20	0	49	0.88	2.95
and intact surfaces	5—6	0— 7	0	35	0.68	1.66	0— 8	0	38	0.87	1.56	0— 4	0	49	0.30	0.76
Total develop-	1—2	0— 4	0	35	0.12	0.69	0— 1	0	38	0.05	0.23	0— 0	0	49	0.00	0.00
ment, cumulative	1—3	0— 6	0	35	0.50	1.37	0—15	0	38	1.52	2.84	0—18	0	49	1.32	3.02
(NF_{tot})	1—5	0—10	0	35	1.35	2.45	0—26	0	38	2.15	4.43	0—20	1	49	2.20	3.97
	1—6	0—10	1	35	2.03	2.95	0—26	2	38	3.03	4.48	0—22	1	49	2.50	4.12
Substitution of	1—2	0— 4	0	35	0.12	0.69	0— 0	0	38	0.00	0.00	0— 0	0	49	0.00	0.00
caries increment	2—3	0— 2	0	35	0.15	0.44	0— 6	0	38	0.63	1.17	0— 4	0	49	0.50	0.95
and intact	3—4	0— 1	0	35	0.06	0.24	0— 1	0	38	0.03	0.16	0— 1	0	49	0.04	0.20
surfaces	4—5	0— 2	0	35	0.18	0.46	0— 5	0	38	0.21	0.93	0— 3	0	49	0.26	0.69
	5—6	0— 5	0	35	0.21	0.88	0— 3	0	38	0.34	0.71	0— 1	0	49	0.10	0.30
Cumulative	1—2	0— 4	0	35	0.12	0.69	0— 0	0	38	0.00	0.00	0— 0	0	49	0.00	0.00
development	1—3	0— 4	0	35	0.26	0.79	0— 6	0	38	0.63	1.17	0— 4	0	49	0.50	0.95
($NF_{\Delta c+i}$)	1—4	0— 4	0	35	0.32	0.81	0— 6	0	38	0.66	1.17	0— 4	0	49	0.54	1.01
	1—5	0— 4	0	35	0.50	0.90	0—11	0	38	0.87	1.89	0— 4	0	49	0.80	1.10
	1—6	0— 5	0	35	0.71	1.29	0—11	1	38	1.21	1.93	0— 4	0	49	0.90	1.16
Substitution of	1—2	0— 0	0	35	0.00	0.00	0— 0	0	38	0.00	0.00	0— 0	0	49	0.00	0.00
intact surfaces	2—3	0— 1	0	35	0.03	0.17	0— 1	0	38	0.05	0.23	0— 6	0	49	0.18	0.90
	3—4	0— 0	0	35	0.00	0.00	0— 0	0	38	0.00	0.00	0— 0	0	49	0.00	0.00
	4—5	0— 2	0	35	0.09	0.38	0— 0	0	38	0.00	0.00	0— 0	0	49	0.00	0.00
	5—6	0— 1	0	35	0.06	0.24	0— 1	0	38	0.05	0.23	0— 0	0	49	0.00	0.00
Cumulative	1—2	0— 0	0	35	0.00	0.00	0— 0	0	38	0.00	0.00	0— 0	0	49	0.00	0.00
development	1—3	0— 1	0	35	0.03	0.17	0— 1	0	38	0.05	0.23	0— 6	0	49	0.18	0.90
(NF_i)	1—4	0— 1	0	35	0.03	0.17	0— 1	0	38	0.05	0.23	0— 6	0	49	0.18	0.90
	1—5	0— 2	0	35	0.12	0.41	0— 1	0	38	0.05	0.23	0— 6	0	49	0.18	0.90
	1—6	0— 2	0	35	0.18	0.46	0— 1	0	38	0.11	0.31	0— 6	0	49	0.18	0.90

CS 2-lesions. A direct development from a noncarious filled surface to a 2-type lesion was rare. The results are shown in Tables XI, XII, and Fig. 5 c, d.

Development from CS 1- to CS 2-lesions. Changes in size of the secondary lesions occurred only in sporadic cases. The results are shown in Tables XIII, XIV, and Fig. 5 e, f.

Significance levels. Despite the cumulative net increment of secondary carious lesions being in general lower in the X-group than in the two other groups, there were no significant differences found with regard to these parameters (Table XXV).

Filled surfaces

The number of the new filled surfaces was calculated as described in »Material and methods». The new fillings appearing at

Table XVI. *Cumulative total clinical caries net increment. Sum of C 1, C 2, CS 1 and CS 2-type reversals*

	Term	Sucrose R_s	Md	N	$\bar{x}$	S.D.$_s$	Fructose R_f	Md	N	$\bar{x}$	S.D.$_f$	Xylitol R_x	Md	N	$\bar{x}$	S.D.$_x$
	2	0—10	2.5	33	2.6	2.32	0— 8	2.0	38	2.8	2.3	0— 7	2.0	49	2.4	1.67
Positive	3	0—11	2.0	35	3.3	2.80	0—12	2.5	38	2.9	2.8	0— 8	2.0	49	2.2	2.08
reversals	4	0— 7	2.0	34	2.1	2.31	0— 7	2.0	38	2.1	2.1	0—10	1.0	49	1.4	1.89
0 → (C1 + C2 +	5	0— 8	1.0	35	2.4	2.20	0— 7	1.0	38	1.8	1.8	0— 4	1.0	49	0.7	0.86
CS1 + CS2)	6	0—16	2.0	35	2.8	2.93	0—10	2.0	38	2.6	2.1	0—10	1.0	49	1.3	1.79
Negative	2	0— 7	2.0	33	2.1	1.94	0—11	1.5	38	2.0	2.3	0—10	2.0	49	2.0	2.06
reversals	3	0— 6	1.0	35	1.5	1.42	0— 8	1.0	38	1.9	1.8	0— 7	2.0	49	1.8	1.73
(C1 + C2 +	4	0— 5	0.0	34	1.0	1.40	0— 6	1.0	38	1.5	1.6	0— 7	1.0	49	1.5	1.80
CS1 + CS2) → 0	5	0— 5	1.0	35	1.2	1.45	0— 4	1.0	38	1.3	1.2	0— 4	0.0	49	1.1	1.35
	6	0— 3	0.0	35	0.6	0.82	0— 3	0.0	38	0.6	0.8	0— 8	0.0	49	0.5	1.28
Net	2	—4—10	0.0	33	0.5	3.03	—9— 6	1.0	38	0.8	2.8	— 8— 5	1.0	49	0.5	2.41
increment	3	—5—10	1.0	35	1.8	3.04	—5—11	1.0	38	1.0	2.9	— 7— 6	0.0	49	0.5	2.75
0 ⇌ (C1 + C2 +	4	—5— 7	1.0	34	1.1	2.93	—5— 6	0.0	38	0.6	2.4	— 6—10	0.0	49	—0.0	2.65
CS1 + CS2)	5	—3— 7	1.0	35	1.2	2.59	—3— 5	1.0	38	0.5	1.9	— 4— 2	0.0	49	—0.4	1.51
	6	—2—14	1.0	35	2.2	2.72	—1— 9	2.0	38	2.0	2.1	— 8—10	1.0	49	0.7	2.32
Cumulative	2—3	0—17	5.0	35	5.7	4.03	0—16	6.0	38	5.7	4.1	0—14	4.0	49	4.7	3.10
positive reversals	2—4	0—22	7.0	35	7.8	5.41	0—21	8.0	38	7.8	5.3	0—17	5.0	49	6.1	4.07
0 → (C1 + C2	2—5	0—27	8.0	35	10.2	6.76	0—24	10.0	38	9.6	6.4	0—19	6.0	49	6.8	4.31
+ CS1 + CS2)	2—6	3—39	10.5	35	13.0	8.27	1—34	12.5	38	12.2	7.8	0—22	7.0	49	8.1	4.85
Cumulative	2—3	0— 9	3.0	35	3.5	2.26	0—11	4.0	38	4.0	3.2	0—12	3.5	49	3.8	3.07
negative reversals	2—4	0—10	4.0	35	4.5	2.90	1—14	4.5	38	5.5	3.8	0—14	5.0	49	5.2	3.81
(C1 + C2 +	2—5	0—11	5.5	35	3.7	3.23	1—18	6.0	38	6.8	4.3	0—17	6.0	49	6.3	4.20
CS1 + CS2) → 0	2—6	0—12	6.0	35	6.3	3.24	1—19	6.0	38	7.3	4.7	0—20	6.0	49	6.8	4.66
Cumulative	2	—4—10	0.0	33	0.5	3.03	—9— 6	1.0	38	0.8	2.8	— 8— 5	1.0	49	0.5	2.41
net	2—3	—4—14	1.0	35	2.3	4.20	—6—10	1.0	38	1.8	3.3	—11— 8	1.0	49	0.9	3.79
increment	2—4	—4—19	2.0	35	3.3	5.46	—6—12	2.0	38	2.3	4.2	—12—15	0.5	49	0.9	4.67
0 ⇌ (C1 + C2	2—5	—4—22	3.0	35	4.5	6.63	—5—15	2.0	38	2.8	4.4	—12—12	0.0	49	0.5	4.55
+ CS1 + CS2)	2—6	—3—34	5.0	35	6.8	7.99	—4—24	4.0	38	4.9	5.3	—15—15	1.0	49	1.3	5.49

C 1, C 2-, CS 1- and CS 2-reversals have thus been included in the tables and graphs (Tables III—XIV, Figs. 4, 5) showing the development of these reversals.

Table XV shows the number of new fillings, first expressed as the total number of all new filled surfaces replacing caries at the baseline examination, substituting positive caries reversals at the subsequent examinations, and also at locations found clinically and radiographically intact (Fig. 2). The table also shows the number of new fillings replacing the positive caries reversals, and separately, the number of new filled surfaces at clinically and radiographically intact tooth surfaces (Table XV, Fig. 2).

Fig. 6 shows separately the total number of new fillings, and the number of fillings at surfaces found to be intact or positive

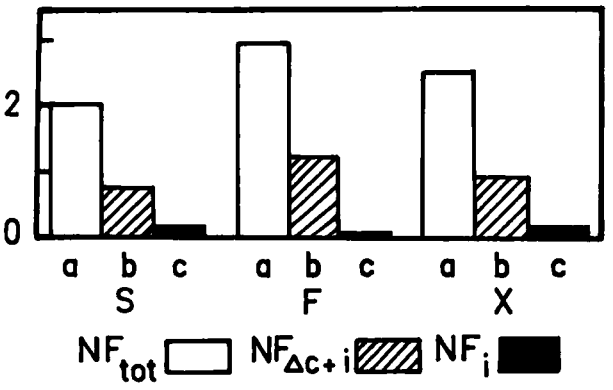

Fig. 6. Number of new filled surfaces after one year of selective sugar diets,
a. Total number of new fillings, replacing caries at baseline examination, substituting positive caries reversals at subsequent examinations, and also at clinically and radiographically intact tooth surfaces
b. Number of new fillings replacing positive caries reversals, and at intact tooth surfaces
c. Number of new fillings at clinically and radiographically intact tooth surfaces

reversals. The number of new fillings at surfaces found clinically and radiographically intact was 0.18 in the S-group, 0.11 in the F-group, and 0.18 in the X-group. It was taken in account when calculating the total caries incidence.

Missed surfaces

The number of missed surfaces was calculated as described in materials and methods. Tooth extractions occurred only in a few cases, and had virtually no influence on the results. The number of missed surfaces was taken into account when calculating the total caries incidence.

Combined caries indices

Caries net increment. The clinical caries net increment was calculated as the difference between the positive and negative reversals of the sum of the C 1-, C 2-, CS 1- and CS 2-lesions (Table XVI). The cumulative development of the clinical caries net increment is shown in Table XVI and Fig. 7 a, the difference between X- and S-groups, and X- and F-groups being highly significant (Table XXVI).

The development of clinically and additional radiographically detected reversals, the net increment and the cumulative net increment is shown combined for all lesions (C 1 + C 2 + CS 1 + CS 2) in Table XVII and Fig. 7 b, the difference between the X- and S-groups, and the X- and F-groups being highly significant (Table XXVI).

Increase in lesion size. The clinical reversals in lesion size, shown for all lesions (C 1⇌ CS 1⇌ CS 2) in Table XVIII and Fig. 7 c. The corresponding clinically and additional radiographically detected findings are shown in Table XIX and Fig. 7 d, the differences only between the X- and S-group being significant (Table XXVI).

Sum of quantitative and qualitative reversals. The combined development in the number and size of the lesions is shown separately for clinically detected (Table XX, Fig. 7 e) and clinically and additional radiographically detected reversals (Table XXI, Fig. 7 f), the differences between the X- and S-groups, and the X- and S-groups being highly significant (Table XXVI).

Total number of DMF- and intact tooth surfaces. The development of the number of DMF-surfaces and its cumulative changes (Table XXI, Fig. 8) concede the total loss of intact tooth surfaces during the study. Qualitative changes were thus not considered, nor the variations between

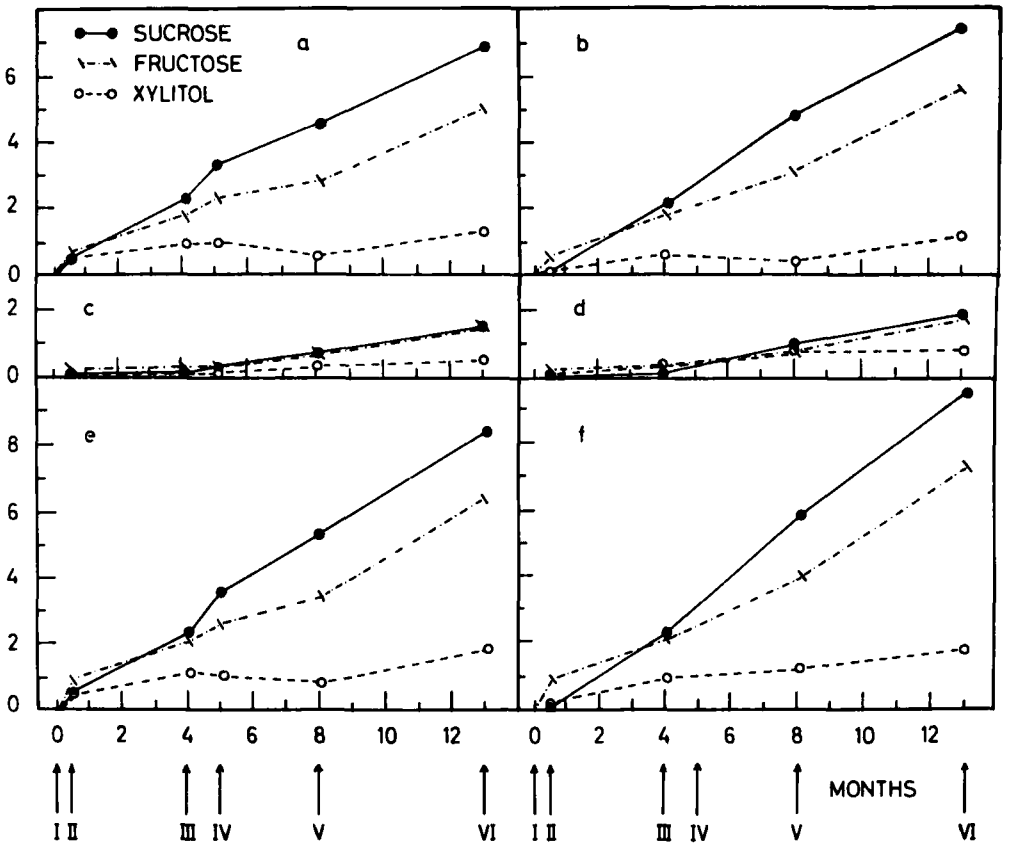

Fig. 7. Cumulative net increment of primary and secondary caries reversals,
a. All clinically detected reversals, C 1 + C 2 + CS 1 + CS 2
b. All clinically and radiographically detected reversals, (C 1 + C 2 + CS 1 + CS 2) + (CR 1 + CR 2 + CSR 1 + CSR 2)
c. Increase in size of clinical lesions, (C 1 ⇌ C 2) + (CS 1 ⇌ CS 2)
d. Increase in size of clinical and radiographical lesions, (C 1 ⇌ C 2) + (CS 1 ⇌ CS 2) + (CR 1 ⇌ CR 2) + (CSR 1 ⇌ CSR 2)
e. Clinical quantitative and qualitative development, (C 1 + C 2 + CS 1 + CS 2) + (C 1 ⇌ C 2) + (CS 1 ⇌ CS 2)
f. Clinical and radiographical quantitative and qualitative development, (C 1 + C 2 + CS 1 + CS 2) + (CR 1 + CR 2 + CSR 1 + CSR 2) + (C 1 ⇌ C 2) + (CS 1 ⇌ CS 2) + (CR 1 ⇌ CR 2) + (CSR 1 ⇌ CSR 2)

filled and secondary carious surfaces. The differences between the X-group, and on the other hand, the F- and S-groups were highly significant (Table XXVI). The total loss of intact tooth surfaces was thus 5.0 in the S-group, 3.8 in the F-group, and 0.5 in the X-group.

Caries activity index. This index covers not only the loss of intact tooth surfaces as defined above, but also all qualitative changes in lesion size and all secondary carious lesions. The total number of these qualitative and quantitative changes at the various registrations, and the cumulative development is shown in Table XXIII and Fig. 9 a, the difference between the X- and S-groups, and the X- and F-groups being highly significant (Table XXVI).

Total caries incidence, quantitative changes. The caries increment during the

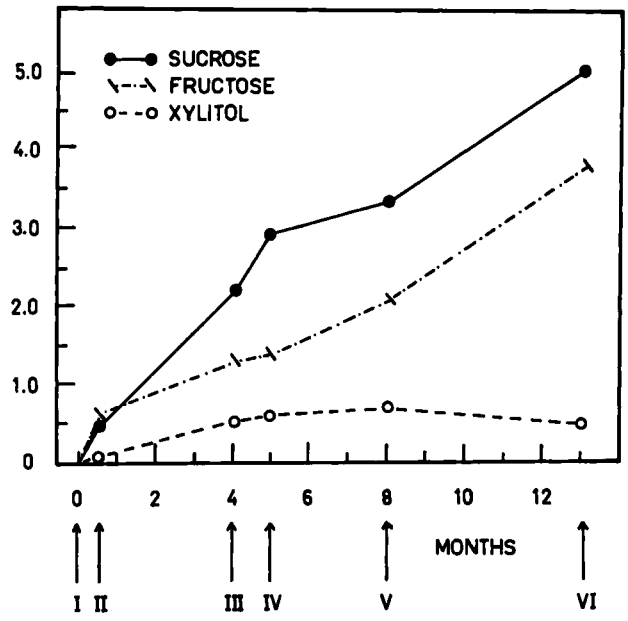

Fig. 8. Cumulative development of decayed, missed and filled tooth surfaces (△DMFS).

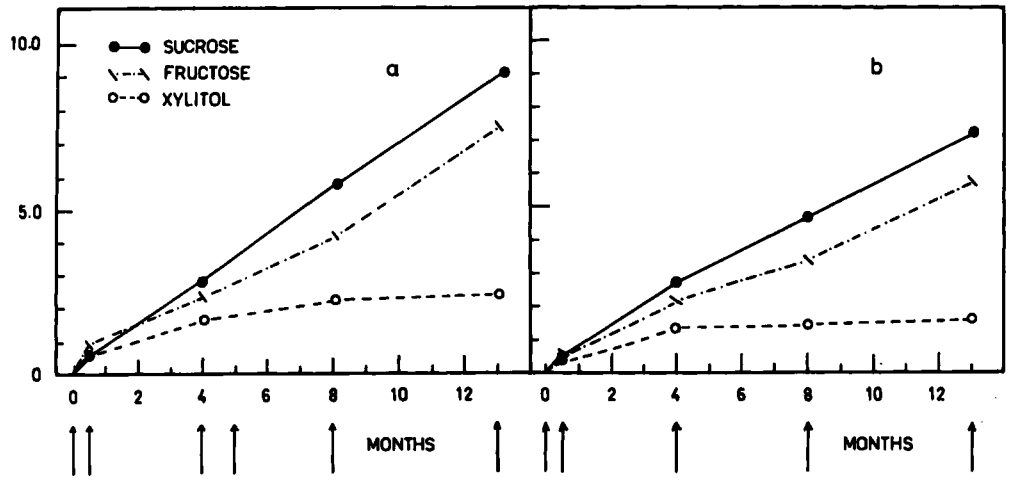

Fig. 9. Total caries activity after one year of selective sugar diets,
a. Sum of all quantitative and qualitative changes, including cumulative development of DMF-surfaces (Fig. 8), all secondary caries reversals (Fig. 5 b, d), and all qualitative changes in lesion size (Fig. 7 d).
b. Sum of all quantitative changes, including cumulative development of DMF-surfaces (Fig. 8), and all secondary caries reversals (Fig. 5 b, d).

Table XVII. *Cumulative total clinical and radiographical caries net increment. Sum of C 1-, C 2-, CS 1-, CS 2-, CR 1-, CR 2-, CSR 1- and CSR 2-type reversals*

	Term	Sucrose R_s	Md	N	$\bar{x}$	S.D.$_s$	Fructose R_f	Md	N	$\bar{x}$	S.D.$_f$	Xylitol R_x	Md	N	$\bar{x}$	S.D.$_x$
	2	0—10	2.5	33	2.8	2.34	0— 8	3.0	38	3.0	2.2	0— 7	2.0	49	2.6	1.70
Positive	3	1—12	3.0	35	4.1	2.97	0—12	3.0	38	4.0	3.1	0—10	2.5	49	3.2	2.41
reversals*	5	0—16	4.0	34	5.6	4.58	0—15	4.0	38	4.8	3.4	0—13	2.0	49	3.1	2.67
	6	0—25	3.0	35	3.9	4.35	0—10	3.0	38	3.6	2.4	0—10	2.0	49	2.0	1.94
	2	0— 7	2.5	33	2.6	1.95	0—12	2.0	38	2.4	2.5	0—11	2.0	49	2.5	2.14
Negative	3	0— 7	1.0	35	2.1	1.73	0— 8	3.0	38	2.8	1.8	0— 7	3.0	49	2.7	1.88
reversals	5	0— 7	3.0	34	2.9	1.87	0—11	3.0	38	3.4	2.4	0—10	3.0	49	3.3	2.66
	6	0— 4	1.0	35	1.3	1.05	0— 6	1.0	38	1.3	1.5	0— 9	1.0	49	1.4	1.54
	2	—4—10	0.0	33	0.1	2.89	—10— 6	0.0	38	0.6	2.9	— 8— 5	0.0	49	0.1	2.49
Net	3	—5—10	1.0	35	2.0	3.23	— 4—10	1.0	38	1.2	3.1	— 5— 8	1.0	49	0.5	3.00
increment	5	—6—12	1.0	34	2.7	4.63	— 4—11	0.5	38	1.3	3.1	— 7—10	0.0	49	—0.2	3.37
	6	—2—23	1.5	35	2.6	4.14	— 3— 9	2.0	38	2.3	2.8	— 9—10	0.5	49	0.7	2.80
Cumulative	2—3	1—17	6.0	35	6.7	4.06	0—16	7.0	38	7.0	4.4	1—16	5.5	49	5.8	3.43
positive	2—5	2—29	10.0	35	12.1	7.52	0—26	11.5	38	11.8	6.7	3—22	8.0	49	8.8	4.82
reversals	2—6	3—49	13.0	35	16.1	9.98	2—36	15.5	38	15.4	8.3	3—25	10.5	49	10.9	5.53
Cumulative	2—3	0—10	4.0	35	4.6	2.56	0—14	4.5	38	5.2	3.4	0—14	4.5	49	5.1	3.22
negative	2—5	1—14	7.0	35	7.4	3.51	1—20	8.0	38	8.7	4.6	0—20	7.5	49	8.4	4.63
reversals	2—6	2—15	9.0	35	8.6	3.88	2—21	9.0	38	10.0	5.1	0—21	8.5	49	9.8	4.92
Cumulative	2	—4—10	0.0	33	0.1	2.89	—10— 6	0.0	38	0.6	2.9	— 8— 5	0.0	49	0.1	2.49
net	2—3	—3—13	1.0	35	2.1	4.14	— 9—10	1.5	38	1.8	3.7	—11— 9	1.0	49	0.6	4.13
increment	2—5	—4—21	4.0	35	4.8	6.74	— 8—15	3.0	38	3.1	4.8	—10—14	0.0	49	0.4	5.23
	2—6	—3—40	5.5	35	7.4	9.12	— 4—24	5.5	38	5.4	5.7	—16—17	1.5	49	1.1	6.08

* $0 \rightarrow (C\,1 + C\,2 + CS\,1 + CS\,2 + CR\,1 + CR\,2 + CSR\,1 + CSR\,2)$

study was also calculated on the basis of the sum of all quantitative changes, including in addition to the increment in number of decayed, missed and filled tooth surfaces (△DMFS), also the corresponding development in the number of all secondary caries reversals. The total number of all quantitative changes at the registrations, and the cumulative development is shown in Table XXIV and Fig. 9 b, the differences between the X- and F-group, and the X- and S-group being highly significant (Table XXVI).

DISCUSSION

A long-term clinical trial, aiming at a comparison of the cariogenicity of various sugars, conceals by nature a number of elements influencing the planning of the study in various, even antagonistic ways. From the aspect of incidence of dental caries, the selection of a young, homogeneous age group would have been advantageous. The consideration of the cooperation of the participants, particularly the predicament of enduring the selective sugar diets for 2 years, offered, however, only one choice. The decision

Table XVIII. *Cumulative increase in size of total clinical caries reversals. Sum of C 1 ⇌ C 2- and CS 1 ⇌ CS 2-type development*

		Sucrose					Fructose					Xylitol				
	Term	R_s	Md	N	$\bar{x}$	S.D.$_s$	R_f	Md	N	$\bar{x}$	S.D.$_f$	R_x	Md	N	$\bar{x}$	D.S.$_x$
	2	0—2	0.0	33	0.2	0.45	0—3	0.0	38	0.3	0.7	0—1	0.0	49	0.3	0.45
Positive	3	0—1	0.0	35	0.0	0.17	0—2	0.0	38	0.3	0.5	0—2	0.0	49	0.2	0.49
reversals	4	0—2	0.0	34	0.2	0.44	0—1	0.0	38	0.1	0.3	0—1	0.0	49	0.1	0.30
(C1 ⇌ C2) +	5	0—2	0.0	35	0.5	0.71	0—4	0.0	38	0.5	0.9	0—2	0.0	49	0.2	0.46
(CS1 → CS2)	6	0—5	0.0	35	0.9	1.32	0—5	0.0	38	0.9	1.3	0—2	0.0	49	0.2	0.55
	2	0—1	0.0	33	0.1	0.30	0—2	0.0	38	0.1	0.4	0—6	0.0	49	0.2	0.88
Negative	3	0—1	0.0	35	0.0	0.17	0—2	0.0	38	0.1	0.4	0—2	0.0	49	0.1	0.40
reversals	4	0—1	0.0	34	0.0	0.17	0—3	0.0	38	0.2	0.6	0—2	0.0	49	0.1	0.36
(C2 → C1) +	5	0—0	0.0	35	0.0	0.0	0—2	0.0	38	0.2	0.4	0—1	0.0	49	0.1	0.24
(CS2 → CS1)	6	0—2	0.0	35	0.1	0.44	0—1	0.0	38	0.0	0.2	0—2	0.0	49	0.0	0.28
	2	—1—2	0.0	33	0.1	0.50	—1—3	0.0	38	0.2	0.7	—6—1	0.0	49	0.1	1.03
Net increment	3	—1—1	0.0	35	0.0	0.25	—2—1	0.0	38	0.1	0.5	—2—2	0.0	49	0.1	0.68
(C1 ⇌ C2) +	4	—1—2	0.0	34	0.1	0.48	—3—1	0.0	38	—0.0	0.7	—2—1	0.0	49	0.0	0.45
(CS1 ⇌ CS2)	5	0—2	0.0	35	0.5	0.71	—1—3	0.0	38	0.3	0.9	—1—2	0.0	49	0.2	0.51
	6	—1—5	0.0	35	0.8	1.27	—1—5	0.0	38	0.9	1.4	—2—2	0.0	49	0.2	0.63
Cumulative																
positive	2—3	0—2	0.0	35	0.2	0.46	0—4	0.0	38	0.5	1.0	0—3	0.0	49	0.5	0.74
reversals	2—4	0—2	0.0	35	0.3	0.59	0—5	0.0	38	0.7	1.2	0—3	0.0	49	0.6	0.78
(C1 → C2) +	2—5	0—4	0.0	35	0.8	1.09	0—6	1.0	38	1.1	1.5	0—4	1.0	49	0.8	1.05
(CS1 → CS2)	2—6	0—9	1.0	35	1.8	2.12	0—8	1.5	38	2.0	2.2	0—4	1.0	49	1.0	1.17
Cumulative																
negative	2—3	0—1	0.0	35	0.1	0.33	0—3	0.0	38	0.2	0.6	0—7	0.0	49	0.3	1.10
reversals	2—4	0—1	0.0	35	0.1	0.36	0—4	0.0	38	0.4	0.9	0—7	0.0	49	0.4	1.16
(C2 ⇌ C1) +	2—5	0—1	0.0	35	0.1	0.36	0—5	0.0	38	0.5	1.1	0—7	0.0	49	0.5	1.18
(CS2 ⇌ CS1)	2—6	0—2	0.0	35	0.3	0.58	0—5	0.0	38	0.6	1.2	0—7	0.0	49	0.5	1.23
Cumulative	2	—1—2	0.0	33	0.1	0.50	—1—3	0.0	38	0.2	0.7	—6—1	0.0	49	0.1	1.03
net increment	2—3	—1—2	0.0	35	0.1	0.49	0—4	0.0	38	0.3	0.8	—7—3	0.0	49	0.1	1.36
(C1 ⇌ C2) +	2—4	—1—2	0.0	35	0.2	0.67	—2—5	0.0	38	0.3	1.1	—7—3	0.0	49	0.1	1.39
(CS1 ⇌ CS2)	2—5	—1—4	0.0	35	0.7	1.07	—2—5	0.0	38	0.6	1.2	—7—4	0.0	49	0.3	1.47
	2—6	—1—9	1.0	35	1.5	2.03	—1—8	1.0	38	1.5	1.9	—7—4	0.0	49	0.5	1.62

and the planning in general implied further imperfections, i.e. the single-blind concept considered unavoidable, the possibility offered to the participants to belong to a specified sugar group, the small size of the groups, the variations in the sugar intake between individuals, and the unrealistic approach aiming at a total substitution of sucrose through fructose or xylitol. The age distribution of the material (Table I), more than half of the test persons being between 15 to 26 years of age, involved a considerable number of wisdom teeth erupting or being extracted for other causes than caries during the trial. For this reason, the number of these teeth and

Table XIX. *Cumulative increase in size of total clinical and radiographic reversals. Sum of C 1 ⇌ C 2-, CS 1 ⇌ CS 2-, CR 1 ⇌ CR 2-, and CSR 1 ⇌ CSR 2-type development*

		Sucrose				Fructose				Xylitol			
	Term	R_s	Md	N	$\bar{x}$	S.D.$_s$	R_f	Md	N	$\bar{x}$	S.D.$_f$	R_x	Md	N	$\bar{x}$	S.D.$_x$
	2	0— 2	0.0	33	0.2	0.45	0—3	0.0	38	0.4	0.8	0—2	0.0	49	0.4	0.53
Positive	3	0— 2	0.0	35	0.2	0.50	0—2	0.0	38	0.4	0.5	0—3	0.0	49	0.5	0.79
reversals	5	0— 5	1.0	34	1.0	1.25	0—4	0.5	38	0.8	1.1	0—4	0.0	49	0.6	0.98
	6	0— 5	0.0	35	1.1	1.44	0—6	1.0	38	1.1	1.5	0—2	0.0	49	0.3	0.61
	2	0— 1	0.0	33	0.2	0.40	0—2	0.0	38	0.2	0.5	0—6	0.0	49	0.3	0.92
Negative	3	0— 1	0.0	35	0.1	0.33	0—2	0.0	38	0.3	0.6	0—3	0.0	49	0.2	0.55
reversals	5	0— 1	0.0	34	0.0	0.17	0—4	0.0	38	0.3	0.8	0—2	0.0	49	0.2	0.52
	6	0— 2	0.0	35	0.2	0.54	0—2	0.0	38	0.2	0.5	0—3	0.0	49	0.3	0.68
	2	—1— 2	0.0	33	—0.0	0.59	—1—3	0.0	38	0.2	0.8	—5—2	0.0	49	0.1	1.03
Net	3	—1— 1	0.0	35	0.1	0.54	—2—1	0.0	38	0.1	0.6	—3—2	0.0	49	0.2	0.94
increment	5	0— 5	1.0	34	1.0	1.26	—2—3	0.0	38	0.5	1.1	—1—2	0.0	49	0.4	0.78
	6	—2— 4	0.0	35	0.9	1.37	—2—6	1.0	38	0.9	1.5	—3—2	0.0	49	—0.0	0.94
Cumulative	2—3	0— 2	0.0	35	0.4	0.65	0—4	0.5	38	0.8	1.0	0—4	1.0	49	0.9	0.95
positive	2—5	0— 7	1.0	35	1.4	1.50	0—6	1.0	38	1.6	1.7	0—5	1.0	49	1.5	1.42
reversals	2—6	0—11	2.0	35	2.4	2.64	0—8	2.0	38	2.7	2.5	0—5	1.0	49	1.8	1.55
Cumulative	2—3	0— 2	0.0	35	0.3	0.58	0—3	0.0	38	0.5	0.8	0—7	0.0	49	0.5	1.22
negative	2—5	0— 2	0.0	35	0.3	0.59	0—6	0.0	38	0.6	1.4	0—7	0.0	49	0.7	1.41
reversals	2—6	0— 3	0.0	35	0.5	0.83	0—6	0.0	38	1.0	1.4	0—7	0.0	49	1.0	1.67
Cumulative	2	—1— 2	0.0	33	—0.0	0.59	—1—3	0.0	38	0.2	0.8	—5—2	0.0	49	0.1	1.03
net	2—3	—2— 2	0.0	35	0.1	0.79	—2—4	0.0	38	0.3	1.1	—6—3	0.0	49	0.4	1.51
increment	2—5	0— 5	1.0	35	1.0	1.19	—2—6	0.0	38	0.8	1.7	—5—4	1.0	49	0.8	1.52
	2—6	0— 9	1.0	35	1.9	2.15	—1—8	1.5	38	1.7	2.0	—4—4	1.0	49	0.8	1.57

tooth surfaces at risk varying considerably, the wisdom teeth were considered as a separate group. The calculations in the present paper thus exclude the wisdom teeth, the findings covering the latter being presented separately.

From an opposite point of view, the solidity of the present long-term studies may rest in the general arrangement, the clinical and radiographic findings in relatively small groups being supplemented through versatile biochemical and microbiological analyses, the results from the latter studies providing information supporting and explaining the observations on the caries incidence. Further strength is gained from the independent arrangement of the clinical and radiographic assessment of dental caries, the results thus obtained supporting each other. Also from an ethical point of view, as the participants were not requested to consume sugar-containing products to any larger extent than they were used to, the trial seems acceptable. Still, in order to detect lesions induced by sugar consumption at the earliest possible stage, and to prevent widespread damage to occur, repeated clinical and radiographic inspections were arranged at short intervals.

Table XX. *Cumulative total clinical caries net increment and increase in size of total clinical caries reversals. Sum of C 1-, C 2-, CS 1-, CS 2-, C 1 ⇌ C 2-, CS 1 ⇌ CS 2-type development*

		Sucrose					Fructose					Xylitol				
	Term	R_s	Md	N	$\bar{x}$	S.D.$_s$	R_f	Md	N	$\bar{x}$	S.D.$_f$	R_x	Md	N	$\bar{x}$	S.D.$_x$
	2	0—10	3.0	33	2.8	2.34	0— 9	3.0	38	3.1	2.4	0— 8	2.0	49	2.7	1.82
Positive	3	0—11	2.0	35	3.3	2.82	0—12	2.5	38	3.2	3.0	0—10	2.0	49	2.4	2.32
reversals	4	0— 8	2.0	34	2.2	2.53	0— 7	2.0	38	2.2	2.2	0—11	1.0	49	1.5	2.07
	5	0—10	3.0	35	2.9	2.44	0— 8	2.0	38	2.2	2.1	0— 4	1.0	49	0.9	1.03
	6	0—20	3.0	35	3.8	3.83	0—10	3.0	38	3.5	2.6	0—11	1.0	49	1.5	1.94
	2	0— 7	2.0	33	2.2	1.96	0—11	1.5	38	2.1	2.3	0—12	2.0	49	2.2	2.53
Negative	3	0— 6	1.0	35	1.5	1.48	0— 8	2.0	38	2.1	1.8	0— 7	2.0	49	1.9	1.83
reversals	4	0— 5	0.0	34	1.1	1.43	0— 8	1.0	38	1.7	1.8	0— 7	1.0	49	1.6	1.76
	5	0— 5	1.0	35	1.2	1.45	0— 5	1.0	38	1.4	1.4	0— 4	1.0	49	1.1	1.36
	6	0— 3	1.0	35	0.7	0.83	0— 3	0.0	38	0.6	0.8	0— 8	0.0	49	0.6	1.30
	2	—4—10	0.0	33	0.6	3.05	—6— 6	1.0	38	0.9	2.7	—11— 6	1.0	49	0.5	2.92
Net	3	—5—10	1.0	35	1.8	3.04	—5—11	1.0	38	1.1	3.0	— 6— 8	0.0	49	0.5	2.92
increment	4	—5— 7	1.0	34	1.7	3.20	—5— 6	0.5	38	0.6	2.5	— 6—11	0.0	49	—0.0	2.71
	5	—3— 9	2.0	35	1.7	2.90	—3— 4	1.0	38	0.8	1.9	— 4— 3	0.0	49	—0.2	1.54
	6	—2—18	2.5	35	3.0	3.57	—1—10	3.0	38	2.9	2.5	— 8—11	1.0	49	0.9	2.46
Cumulative	2—3	0—17	5.0	35	5.9	4.09	0—17	6.0	38	6.3	4.4	0—15	4.5	49	5.2	3.51
positive	2—4	0—22	7.0	35	8.1	5.63	0—23	8.5	38	8.5	5.7	0—19	6.0	49	6.7	4.52
reversals	2—5	0—28	9.0	35	11.0	7.24	0—28	11.0	38	10.7	7.1	0—21	7.0	49	7.6	4.99
	2—6	3—46	11.5	35	14.8	9.76	1—38	14.0	38	14.2	9.0	0—24	8.0	49	9.1	5.58
Cumulative	2—3	0— 9	3.0	35	3.6	2.28	0—11	4.0	38	4.2	3.2	0—17	3.5	49	4.1	3.70
negative	2—4	0—10	4.0	35	4.6	3.00	1—14	5.0	38	5.9	3.9	0—19	5.0	49	5.7	4.36
reversals	2—5	0—12	5.5	35	5.8	3.30	1—18	6.0	38	7.3	4.6	0—20	6.0	49	6.8	4.79
	2—6	0—12	6.5	35	6.6	3.22	1—19	6.5	38	7.9	5.0	0—27	6.0	49	7.3	5.40
	2	—4—10	0.0	33	0.6	3.05	—6— 6	1.0	38	0.9	2.7	—11— 6	1.0	49	0.5	2.92
Cumulative	2—3	—4—14	1.0	35	2.3	4.22	—4—10	1.5	38	2.1	3.1	—14—10	1.0	49	1.1	4.47
net	2—4	—4—19	2.5	35	3.5	5.57	—4—13	3.0	38	2.6	3.9	—15—15	1.0	49	1.0	5.19
increment	2—5	—4—23	4.0	35	5.2	7.12	—3—15	3.5	38	3.4	4.2	—14—12	0.5	49	0.8	5.15
	2—6	—3—41	5.0	35	8.2	9.27	—4—24	7.0	38	6.3	5.6	—22—15	1.5	49	1.8	6.31

An examination of the results (Tables III—XXIV) reveals slight differences in the S-group in the number of test persons examined at various registrations. The variation is due to not all participants turning up at the clinical and radiographical inspections. The cumulative net increment, and the development in general, is not affected by these aberrances.

During the first year of the study the side effects were remarkably few and consisted no problem with regard to the test persons ceasing from participation for this reason. In case this would have been anticipated at the planning phase of the study, the three sugar groups would have been rendered equal in size, which in turn would have added to the precision of the results. At present, when testing differences between the X- and S-groups, and the F-

Table XXI. *Cumulative total clinical and radiographic caries net increment, and increase in size of total clinical and radiographic caries reversals. Sum of C 1-, C 2-, CS 1-, CS 2-, CR 1-, CR 2-, CSR 1-, CSR 2-, C 1 ⇌ C 2-, CS 1 ⇌ CS 2-, CR 1 ⇌ CR 2- and CSR 1 ⇌ CSR 2-type development*

		Sucrose					Fructose					Xylitol				
	Term	R_s	Md	N	$\bar{x}$	$S.D._s$	R_f	Md	N	$\bar{x}$	$S.D._f$	R_x	Md	N	$\bar{x}$	$S.D._x$
	2	0—10	3.0	33	2.9	2.37	0—10	3.5	38	3.4	2.5	0— 9	2.5	49	3.0	1.85
Positive	3	1—12	3.0	35	4.4	3.12	0—13	4.0	38	4.3	3.3	0—12	3.0	49	3.7	2.68
reversals	5	0—21	5.0	34	6.6	5.39	0—17	5.0	38	5.6	4.0	0—14	3.0	49	3.7	2.94
	6	0—29	4.0	35	5.0	5.30	0—12	4.0	38	4.7	3.1	0—11	2.0	49	2.3	2.07
	2	0— 8	2.5	33	2.8	2.13	0—12	2.0	38	2.6	2.5	0—12	2.0	49	2.7	2.57
Negative	3	0— 7	1.5	35	2.2	1.79	0— 8	3.0	38	3.1	1.8	0— 8	3.0	49	2.9	2.06
reversals	5	0— 7	3.0	34	2.9	1.89	0—13	3.0	38	3.8	2.7	0—10	3.0	49	3.5	2.73
	6	0— 5	1.0	25	1.5	1.24	0— 7	1.0	38	1.5	1.8	0— 9	1.0	49	1.7	1.71
	2	5—10	0.0	33	0.1	3.03	—7— 6	1.0	38	0.8	2.8	—10— 6	1.0	49	0.2	2.92
Net	3	—5—10	1.0	35	2.1	3.32	—4—11	1.0	38	1.2	3.3	— 5— 9	1.0	49	0.8	3.07
increment	5	—6—17	1.0	34	3.7	5.48	—6—11	1.0	38	1.8	3.4	— 7—11	0.0	49	0.2	3.45
	6	—2—27	2.0	35	3.5	5.00	—4—10	3.0	38	3.2	3.3	— 8—11	1.0	49	0.7	2.92
Cumulative	2—3	2—17	7.0	35	7.1	4.20	0—19	7.5	38	7.8	4.8	1—17	6.0	49	6.6	3.83
positive	2—5	3—36	12.0	35	13.5	8.40	0—30	13.0	38	13.4	7.7	3—24	9.0	49	10.3	5.46
reversals	2—6	3—56	15.0	35	18.5	12.08	2—40	18.0	38	18.1	9.9	3—26	12.5	49	12.7	6.15
Cumulative	2—3	0—10	5.0	35	4.9	2.78	0—14	5.0	38	5.7	3.4	0—18	5.0	49	5.6	3.86
negative	2—5	1—14	7.0	35	7.7	3.68	1—21	8.5	38	9.5	4.9	1—25	8.0	49	9.2	5.31
reversals	2—6	2—16	9.0	35	9.1	4.08	2—23	10.0	38	11.0	5.6	1—28	9.5	49	10.8	5.86
Cumulative	2	—5—10	0.0	33	0.1	3.03	—7— 6	1.0	38	0.8	2.8	—10— 6	1.0	49	0.2	2.92
net	2—3	—3—13	1.0	35	2.2	4.31	—5— 9	1.0	38	2.1	3.6	—13—12	1.0	49	1.0	4.62
increment	2—5	—3—23	5.0	35	5.8	7.45	—4—14	3.5	38	3.9	4.8	—12—16	1.0	49	1.2	5.51
	2—6	—3—47	6.5	35	9.4	10.80	—4—23	7.5	38	7.1	5.9	—20—16	2.0	49	1.8	6.40

and S-groups, the detection of significant differences relative to the X-group is favoured to some extent due to the larger size of this group. The risk of not being able to discern an existing significant difference in the case of 38 participants, when it would be observable with 50 participants, is calculated to about 15 %.

The difference in the incidence of caries between the F- and S-groups, although not significant as measured with the distribution-free statistical methods employed, is around 25 %. In case of the present development continuing also during the second year of the study, the differences between the F- and S-groups may turn out to be significant. In addition, the evaluation of a part of the results by using conventional parametric tests may also yield significant differences so far not established.

The difference in the caries incidence between the X- and S-groups far exceeds the expectations of the authors. It should be noted that the caries increment rate is calculated in various ways in order to cover separately the quantitative changes in the form of number of lesions, and the

Table XXII. *Total number of decayed, missed and filled tooth surfaces. Cumulative increment of DMFS-index (△DMFS)*

Term	Sucrose R_s	Md	N	$\bar{x}$	S.D.$_s$	Fructose R_f	Md	N	$\bar{x}$	S.D.$_f$	Xylitol R_x	Md	N	$\bar{x}$	S.D.$_x$
1	6—80	47.5	35	44.0	16.69	23—75	45.5	38	47.7	14.3	18—104	49.5	49	50.7	18.34
2	6—80	45.5	33	43.0	16.31	24—73	47.5	38	48.3	13.7	18—100	50.5	49	50.8	18.47
3	8—90	50.0	35	46.2	18.21	26—74	47.0	38	49.0	13.4	19— 97	50.0	49	51.1	18.31
4	7—94	50.0	35	46.9	18.72	27—75	47.0	38	49.1	13.4	19— 98	51.0	49	51.2	18.25
5	7—91	50.5	35	47.3	18.32	25—74	48.5	38	49.9	13.5	19— 99	51.0	49	51.3	18.16
6	9—96	53.0	35	49.0	18.28	24—76	47.5	38	51.6	14.5	22— 92	49.5	49	51.2	18.02
1—2	—10— 9	0.0	33	0.5	3.30	— 8— 4	1.0	38	0.6	2.3	— 5— 4	0.0	49	0.1	2.13
1—3	— 4—12	2.0	35	2.2	3.75	— 6— 7	1.0	38	1.3	3.1	— 8— 10	0.0	49	0.5	3.79
1—4	— 4—15	2.0	35	2.9	4.70	— 6—10	2.0	38	1.4	3.6	— 8— 17	0.5	49	0.6	4.38
1—5	— 4—17	2.0	35	3.3	5.01	— 5—14	2.0	38	2.1	3.9	—10— 13	1.0	49	0.7	4.59
1—6	— 5—17	3.0	35	5.0	5.80	— 5—20	2.5	38	3.8	4.6	—12— 15	1.0	49	0.5	5.30

Table XXIII. *Cumulative increment of quantitative and qualitative reversals. Sum of increment in number of decayed, missed and filled tooth surfaces (△DMFS), all secondary caries reversals (F → CS 1, F → CS 2, F → CSR 1, F → CSR 2), and increase in size of total clinical and radiographic reversals (C 1 ⇌ C 2, CS 1 ⇌ CS 2, CR 1 ⇌ CR 2, CSR 1 ⇌ CSR 2)*

Term	Sucrose R_s	Md	N	$\bar{x}$	S.D.$_s$	Fructose R_f	Md	N	$\bar{x}$	S.D.$_f$	Xylitol R_x	Md	N	$\bar{x}$	S.D.$_x$
1—2	—8—10	1.0	33	0.5	3.34	—6— 5	1.0	38	0.9	2.3	— 9— 7	1.0	49	0.5	2.65
2—3	—3—16	1.5	33	1.9	3.75	—5—10	1.5	38	1.4	3.4	— 4—13	1.0	49	1.1	3.31
3—5	—3—11	1.0	34	2.2	3.11	—6— 8	2.0	38	1.7	2.8	— 6— 7	0.0	49	0.5	2.92
5—6	—3—23	2.0	35	3.4	4.99	—5—14	3.0	38	3.3	4.0	— 9— 9	0.0	49	0.2	3.40
1—2	—8—10	1.0	33	0.5	3.34	—6— 5	1.0	38	0.9	2.3	— 9— 7	1.0	49	0.5	2.65
1—3	—3—13	1.5	35	2.8	4.25	—5— 9	1.5	38	2.3	3.3	—13—15	1.0	49	1.6	4.57
1—5	—3—22	5.0	35	5.7	6.84	—3—15	4.0	38	4.1	4.4	—10—20	1.0	49	2.2	5.77
1—6	—4—42	7.0	35	9.1	9.86	—3—23	7.5	38	7.4	5.5	—16—20	2.0	49	2.4	6.68

Table XXIV. *Cumulative increment of quantitative reversals. Sum of increment in number of decayed, missed and filled tooth surfaces (△DMFS) and all secondary caries reversals (F⇌ CS 1, F⇌ CS 2, F⇌ CSR 1, F⇌ CSR 2)*

Term	Sucrose R_s	Md	N	$\bar{x}$	S.D.$_s$	Fructose R_f	Md	N	$\bar{x}$	S.D.$_f$	Xylitol R_x	Md	N	$\bar{x}$	S.D.$_x$
1—2	—9—10	1.0	33	0.5	3.40	—9— 5	1.0	38	0.8	2.53	— 5— 6	0.0	49	0.3	2.12
2—3	—3—19	1.5	33	2.0	4.15	—6—10	1.5	38	1.5	3.93	— 6—12	1.0	49	0.9	3.76
3—5	—5—10	0.0	34	1.8	3.78	—5—11	0.5	38	1.3	3.48	— 7—10	0.0	49	0.2	3.54
5—6	—4—20	2.0	35	2.9	4.61	—5—14	2.0	38	2.3	3.95	— 8— 8	0.0	49	0.2	3.76
1—2	—9—10	1.0	33	0.5	3.40	—9— 5	1.0	38	0.8	2.53	— 5— 6	0.0	49	0.3	2.12
1—3	—2—12	1.5	35	2.4	3.71	—6—10	2.0	38	2.2	3.94	— 7—13	0.5	49	1.2	4.33
1—5	—3—20	4.0	35	4.2	5.55	—5—15	2.5	38	3.5	4.97	— 8—18	1.0	49	1.4	5.28
1—6	—4—25	5.0	35	7.1	7.57	—4—23	4.0	38	5.8	5.39	—13—19	2.0	49	1.6	6.66

Table XXV. *Significance level of differences in primary and secondary caries incidence between sugar groups after one year of diet*

Variable	Symbol	Figure	Table	Kruskal-Wallis	Mann-Whitney X<S	X<F	U-test F<S
Primary caries, cumulative							
Clinical caries net increment, new incipient lesions	0 ⇌ C 1	4 a	III	++	+++	+	Ø
Clinical and radiographical caries net increment, new incipient lesions	0 ⇌ (C 1+CR 1)	4 b	IV	+++	+++	+	Ø
Clinical caries net increment, new advanced lesions	0 ⇌ C 2	4 c	V	Ø	Ø		
Clinical and radiographical caries net increment, new advanced lesions	0 ⇌ (C 2+CR 2)	4 d	VI	Ø	Ø		Ø
Clinical caries net increase in lesion size	C 1 ⇌ C 2	4 e	VII	+	+++	+	Ø
Clinical and radiographical caries net increase in lesion size	(C 1+CR 1) ⇌ (C 2+CR 2)	4 f	VIII	++	+++	(+)	Ø
Secondary caries, cumulative							
Clinical caries net increment, new incipient lesions	F → CS 1	5 a	IX	Ø	+		
Clinical and radiographical caries net increment, new incipient lesions	F ⇌ (CS 1+CSR 1)	5 b	X	Ø	Ø		
Clinical caries net increment, new advanced lesions	F ⇌ CS 2	5 c	XI	Ø	Ø		
Clinical and radiographical caries net increment, new advanced lesions	F ⇌ (CS 2+CSR 2)	5 d	XII	Ø	Ø		
Clinical caries net increase in lesion size	CS 1 ⇌ CS 2	5 e	XIII	Ø	Ø		
Clinical and radiographical caries net increase in lesion size	(CS 1+CSR 1)⇌(CS 2+CSR 2)	5 f	XIV	Ø	Ø		

$P \leq 0.05$ + Ø = not significant
$P \leq 0.01$ ++
$P \leq 0.005$ +++

qualitative changes appearing as alterations in size of the carious lesions. These indices appear also combined in order to express the total caries activity. In addition, the findings are also presented in the simplest possible way when dealing with samples of the present size, i.e. the increase in number of decayed, missed and filled tooth surfaces. The latter treatment excludes the changes in the size of the lesions, and also all changes between filled and secondary carious surfaces, as a surface can be considered either carious or filled, but not both.

Table XXVI. *Significance level of differences in total cumulative caries incidence between sugar groups after one year of diet*

Variable	Symbol	Figure	Table	Kruskal-Wallis	Mann-Whitney X<S	Mann-Whitney X<F	U-test F<S
Total caries incidence, cumulative							
Total clinical caries net increment	0 ⇌ (C 1+C 2+CS 1+CS 2)	7 a	XVI	+++	+++	+++	Ø
Total clinical and radiographical caries net increment	0 ⇌ [(C 1+C 2+CS 1+CS 2) +(CR 1+CR 2+CSR 1 +CSR 2)]	7 b	XVII	+++	+++	+++	Ø
Total clinical caries net increase in lesion size	(C 1 ⇌ C 2)+(CS 1 ⇌ CS 2)	7 c	XVIII	Ø	+		
Total clinical and radiographical caries net increase in lesion size	(C 1 ⇌ C 2)+(CS 1 ⇌ CS 2)+ (CR 1 ⇌ CR 2)+(CSR 1 ⇌ CSR 2)	7 d	XIX	+	+	Ø	Ø
Total clinical caries net increment + increase in lesion size	0 ⇌ (C 1+C 2+CS 1+CS 2) +(C 1 ⇌ C 2)+(CS 1⇌ CS 2)	7 e	XX	+++	+++	+++	Ø
Total clinical and radiographical caries net increment + increase in lesion size	0 ⇌ [(C 1+C 2+CS 1+CS 2) +(CR 1+CR 2+CSR 1+ CSR 2)]+(C 1 ⇌ C 2)+ (CS 1 ⇌ CS 2)+(CR 1 ⇌ CR 2)+(CSR 1 ⇌ CSR 2)	7 f	XXI	+++	+++	+++	Ø
Total number of decayed, missed and filled tooth surfaces	△DMFS	8	XXII	+++	+++	++	Ø
Sum of all quantitative and qualitative changes	△DMFS+(F ⇌ CS 1)+(F ⇌ CS 2) + (F ⇌ CSR 1) + (F ⇌ CSR 2) + (C 1 ⇌ C 2) + (CS 1 ⇌ CS 2) + (CR 1 ⇌ CR 2) + (CSR 1 ⇌ CSR 2)	9 a	XXIII	+++	+++	+++	Ø
Sum of all quantitative changes	△DMFS + (F ⇌ CS 1) + (F ⇌ CS 2) + (F ⇌ CSR 1) + (F ⇌ CSR 2)	9 b	XXIV	+++	+++	+++	Ø

P ≤ 0.05 + Ø = not significant
P ≤ 0.01 ++
P ≤ 0.005 +++

Regardless of the way of expressing the caries indices in qualitative, quantitative or combined terms, the reduction in the caries incidence in the X-group as compared to the S-group is of a magnitude close to 90 %. In view of the effect, a second long term trial (1-year) involving only partial substitution of sucrose through xylitol was initiated already before the final results from the present 2-year study were available. The intermediate results of the present study should be considered in view of the accompanying biochemical and microbiological findings (*Gehring et al.*, 1974, *Larmas et al.*, 1974; *Mäkinen & Scheinin*, 1974), and also the final reports appearing in 1975. It is, however, evident that the cooperation

regarding the diets turned out to be worse than expected, and the results in the X-group thus better than the cooperation gave reason to assume. A full analysis of the sugar consumption during the study (*Mäkinen & Scheinin*, 1975) will further elucidate the total intake and its variations during the study. The intermediate findings thus clearly show xylitol to be non-cariogenic, and in addition indicate the possibility of a therapeutic and remineralizing effect of xylitol on dental caries.

REFERENCES

Backer Dirks, O., van Amerongen, J. & Winkler, K. C. 1951. A reproducible method for caries evaluation. J. Dent. Res. 30, 346—359

Bradley, J. V. 1968. *Distribution-free statistical tests.* Prentice-Hall, Inc. Englewood Cliffs, New Jersey, N. J.

Carlsson, J. & Egelberg, J. 1965. Effect of diet on early plaque formation in man. Odont. Rev. 16, 112—125

Chilton, N. W. 1967. *Design and analysis in dental and oral research.* J. B. Lippincott Company, Philadelphia & Toronto, pp 365

COCSTOC (Commission on classification and statistics for oral conditions). 1973. Principal requirements for controlled clinical trials of caries preventive agents and procedures. Ed. by *Horowitz, H. S., Baume, L. J., Backer Dirks, O., Davies, G. N. & Slack, G. L.* Int. Dent. J. 23, 506—516

Frostell, G., Keyes, P. H. & Larson, R. H. 1967. Effect of various sugars and sugar substitutes on dental caries in hamsters and rats. J. Nutr. 93, 65—76

Gehring, F., Mäkinen, K. K., Larmas, M. & Scheinin, A. 1974. Turku sugar studies. IV. An intermediate report on the differentiation of polysaccharide forming streptococci (*S. mutans*). Acta Odont. Scand. 32, 435—444

Hassell, Th. M. 1971. pH-Telemetrie der interdentalen Plaque nach Genuss von Zucker und Zuckeraustauschstoffen. Dtsch. Zahnärztl. Z. 26, 1145—1154

Karle, E. & Büttner, W. 1971. Kariesbefall im Tierversuch nach Verabreichung von Sorbit, Xylit, Lycasin und Calciumsaccharosephosphat. Dtsch. Zahnärztl. Z. 26, 1097—1108

Larmas, M., Mäkinen, K. K. & Scheinin, A. 1974. Turku sugar studies. III. An intermediate report on the effect of sucrose, fructose and xylitol diets on the numbers of salivary lactobacilli, candida and streptococci. Acta Odont. Scand. 32, 423—433

Mäkinen, K. K. 1972. The role of sucrose and other sugars in the development of dental caries: A review. Int. Dent. J. 22, 363—386

Mäkinen, K. K. & Scheinin, A. 1971. The effect of the consumption of various sugars on the activity of plaque and salivary enzymes. Int. Dent. J. 331—339

Mäkinen, K. K. & Scheinin, A. 1972. The effect of various sugars and sugar mixtures on the activity and formation of enzymes of dental plaque and oral fluid. Acta Odont. Scand. 30, 259—275

Mäkinen, K. K. & Scheinin, A. 1974. Turku sugar studies. II. Preliminary biochemical and general findings. Acta Odont. Scand. 32, 413—421

Mäkinen, K. K. & Scheinin, A. 1975. Turku sugar studies. VI. The administration of the trial and the control of the diet. Acta Odont. Scand. 33, suppl.

Mühlemann, H. R., Regolati, B. & Marthaler, T. M. 1970. The effect on rat fissure caries of xylitol and sorbitol. Helv. Odont. Acta 14, 48—50

Newbrun, E. 1973. Sugar, sugar substitutes and noncaloric sweetening agents. Int. Dent. J. 23, 328—345

Scheinin, A. 1973. Dietary sugars and sugar substitutes. Int. Dent. J. 23, 427—431

Scheinin, A. & Mäkinen, K. K. 1971. The effect of various sugars on the formation and chemical composition of dental plaque. Int. dent. J. 21, 302—321

Scheinin, A. & Mäkinen, K. K. 1972. The effect of various sugars and sugar mixtures on the formation and chemical composition of dental plaque. Acta Odont. Scand. 30, 235—257

Von der Fehr, F. R., Löe, H. & Theilade, E. 1970. Experimental caries in man. Caries Res. 4, 131—148