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SCIENTIFIC articles

Intraplaque acid formation assessed *in vivo* in children and young adults

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Abstract

For more than ten years, interdental plaque-pH telemetry has been used in Switzerland to investigate the in vivo *acidogenicity and acid clearance time of confectionery, food, beverages and medicines. The measurements are routinely done in adults. For this study, telemetry devices were built into space maintainers of two seven-year-old children and of a fourteen-year-old boy. The pH-changes in the interdental plaque of these volunteers recorded after oral administration of dietary carbohydrates were in agreement with the results routinely found in adults. In both age groups, immediate, pronounced and long lasting pH-falls were recorded under undisturbed layers of plaque at the level of the enamel surface.*

Introduction

Various laboratory and clinical tests have been suggested for the prediction of caries. At the workshop conference on methods of caries prediction in Niagara Falls in 1977, respective experts from all over the world discussed epidemiology, diets, oral biology, caries models and new detection techniques as possible indicators of future caries.[1] They concluded that at present valid, reliable and feasible scientific methods to predict the individual rate of caries incidence are not available. Acid formation in plaque after exposure to fermentable dietary carbohydrates and corresponding decreases of plaque-pH, however, are generally agreed to be closely associated with the initiation of dental decay.

Today intra-oral plaque-pH-telemetry, initiated in 1965 and 1966 by Graf and Mühlemann,[2,3] is still the only *in vivo* method to quickly and accurately assess the hydronium ion concentration under an undisturbed layer of plaque at the level of the enamel surface of the teeth. Plaque-pH telemetry as such, however, cannot be used for an immediate prediction of the cariogenicity of dietary carbohydrates primarily because the individual frequency of consumption is not known.

In spite of this uncertainty in predicting high cariogenicity, or even different degrees of cariogenicity, this method is a valid and feasible way to predict non- or very low cariogenicity.[4] Frequency of consumption can be disregarded if *in vivo* intraplaque acid formation does *not* produce pH-drops below 5.7. The pH-values at or above the arbitrary limit of 5.7 assessed telemetrically after the ingestion of a substance can be regarded as a criterion of a low cariogenic risk for the food. Intraoral telemetry was reviewed and the method described in detail in 1977.[5] Its reproducibility was assessed in a long term retrospective study comparing the findings after administration of standard sucrose rinses in volunteers over periods of 2 to 5 years. The consistency of the results proved to be excellent.[6]

In order to conduct telemetric measurements, the necessary electronic devices and the miniaturized glass pH-electrodes are normally built into modified chrome-steel partial mandibular prostheses.[5] The ideal volunteers therefore are people with a complete natural maxillary dentition as well as natural mandibular front teeth (3-3 or 4-4), and preferentially including the mandibular second molars as abutment teeth. The volunteers have to be available during work hours and should be ready to participate in the program for at least two years. For these reasons the average age of the regular participant is presently 57, the young-

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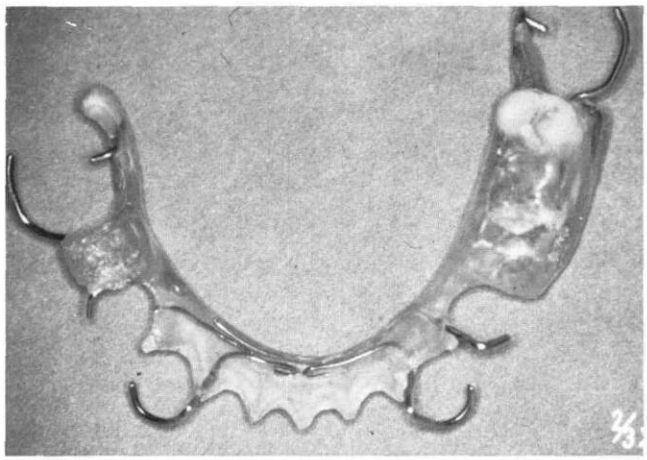

Figure 1. Space maintainer with natural tooth crown incorporating a miniature glass pH-electrode.

est being 32, the oldest 77 years of age. The representativity of this age group for a younger population has never previously been tested. Telemetry in children has not been attempted since they do not ordinarily require partial prostheses and have limited free time during the school week. In addition frequent changes in the dentition would require regular replacement of any appliances made for children.

The purpose of this study was to compare telemetric findings in children and adolescents with those traced in adults.

Methods and Materials

With the approval of their parents, two seven-year-old children and a 14-year-old boy volunteered for the tests. The dentition of all three probands offered the opportunity to build telemetric devices into space maintainers. The two children had suffered from early loss of deciduous teeth and we were given two weeks for our experiments before fixed appliances were inserted for orthodontic treatment. The 14-year-old boy had unfortunately lost a mandibular molar and premolar.

The individual space maintainers were made of cold curing acrylic.* As routinely done for telemetric devices in adults, crowns of natural human teeth, with disto-mesial perforations incorporating miniature glass pH-sensors** were used. They were placed into the space maintainers with the tip of the pH-sensor reaching the artificial interdental spaces created between the perforated tooth crowns in the appliances and the volunteers' abutment teeth (Figure 1). A special plug

*Paladur® white: Kulzer & Co. GmbH, D-6380 Bad Homburg, W. Germany.

**W. Möller, Glasbläserei, CH-8050 Zürich, Switzerland.

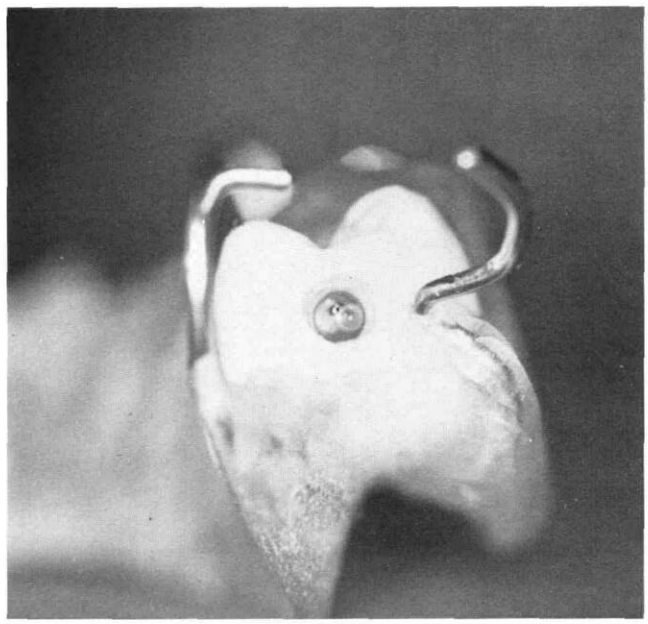

Figure 2. Clean space maintainer before insertion. The tip of the electrode built into a natural tooth crown will face the approximal surface of the volunteer's tooth when inserted.

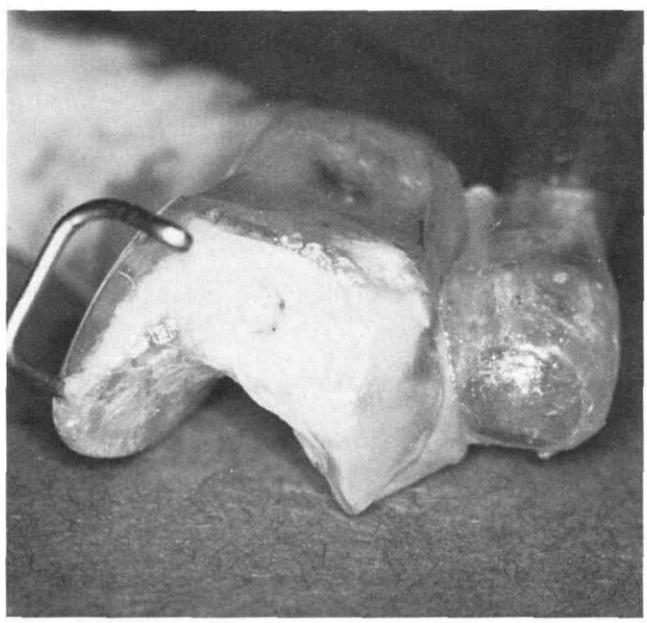

Figure 3. Tip of an interdentally orientated pH-electrode and surrounding enamel covered with four-day-old interdental plaque.

and socket construction enabled the registration of pH-values by means of wire-telemetry, using the recording equipment described earlier.[5]

The space maintainers were inserted and the children were instructed not to change their normal die-

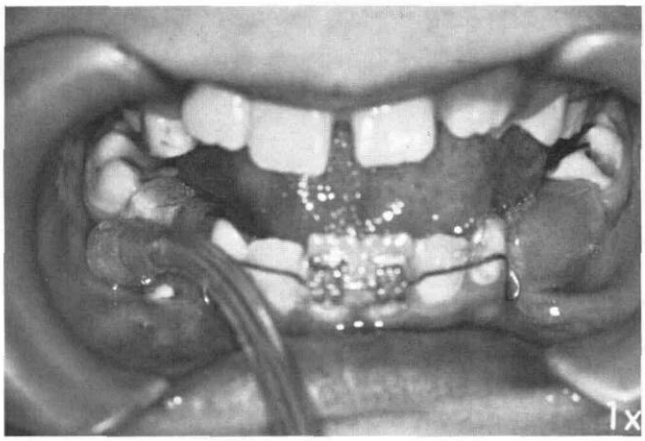

Figure 4. Telemetry space maintainer *in situ* with cable connection during recording. Bracket and wire construction was used to retain appliance.

tary habits. For the six-day test period, they were required to refrain from all oral hygiene measures except for water rinses to remove food debris (Figures 2 and 3). The pH-changes of two- to six-day-old interdental plaques were continuously traced during and subsequent to 15 ml 10% (0.3 mol/1) sucrose rinses (Figure 4). The same sucrose rinses are routinely administered as positive controls in experiments with adults. The plaque-pH behavior was also recorded following the consumption of sucrose containing candies and health-and-fitness preparations commonly consumed by children. At the end of the experimental period, the volunteer's teeth were cleaned by a dental hygienist and they were given a topical fluoride treatment.

Results

Examples of telemetric curves traced during the experimental sessions with the children and tracings after similar sessions with adults are given in Figures 5 to 9.

Discussion

The agreement of the results with children and adult volunteers regarding intraplaque acid production after equal carbohydrate exposures in the present study supports the extrapolation to children of the results from previous plaque pH telemetry studies with adult volunteers only.

The generally higher caries incidence of children is obviously not due to more intraplaque acid production. It must rather be associated with the fact that:

1. Children have more untreated surfaces at risk;
2. Their enamel is not fully mineralized at eruption and has not yet had the benefits of topical fluoride application;
3. Their oral hygiene is poorer; and,
4. Children probably consume more sugar or consume it more frequently than adults.

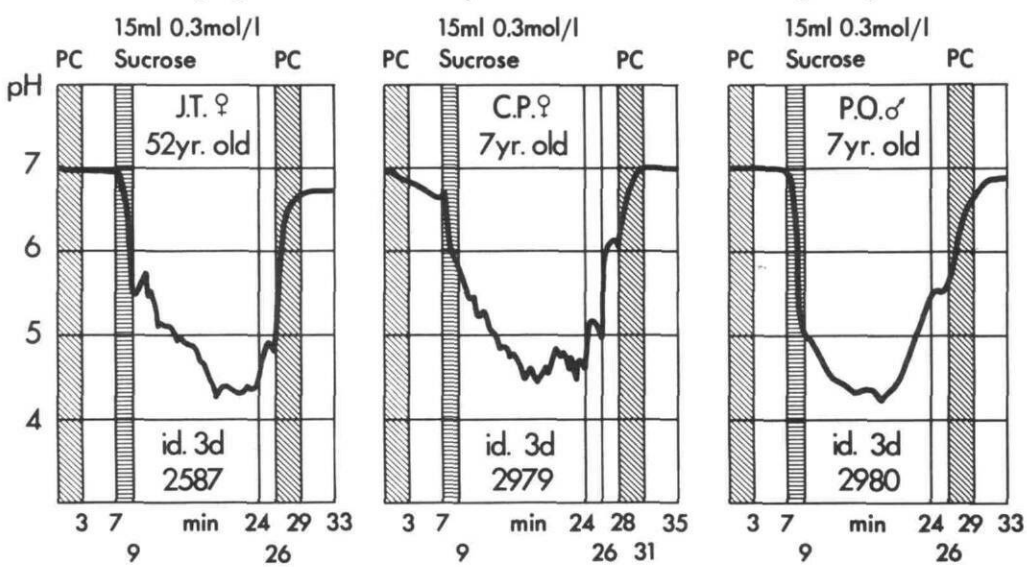

Figure 5. pH-changes of three-day-old interdental plaques during and following two min. rinses with 15 ml 0.3 mol/1 (10%) aqueous sucrose solutions recorded telemetrically in a 52-year-old adult (J.T.) and two seven-year-old children (C.P. and P.O.). PC = Paraffin chewing; d = days, age of plaque. In all three volunteers intraplaque acid formation starting immediately upon rinsing with the sucrose solution depressed the plaque-pH to values of approximately 4.3 within ten min. after expectoration of the solution.

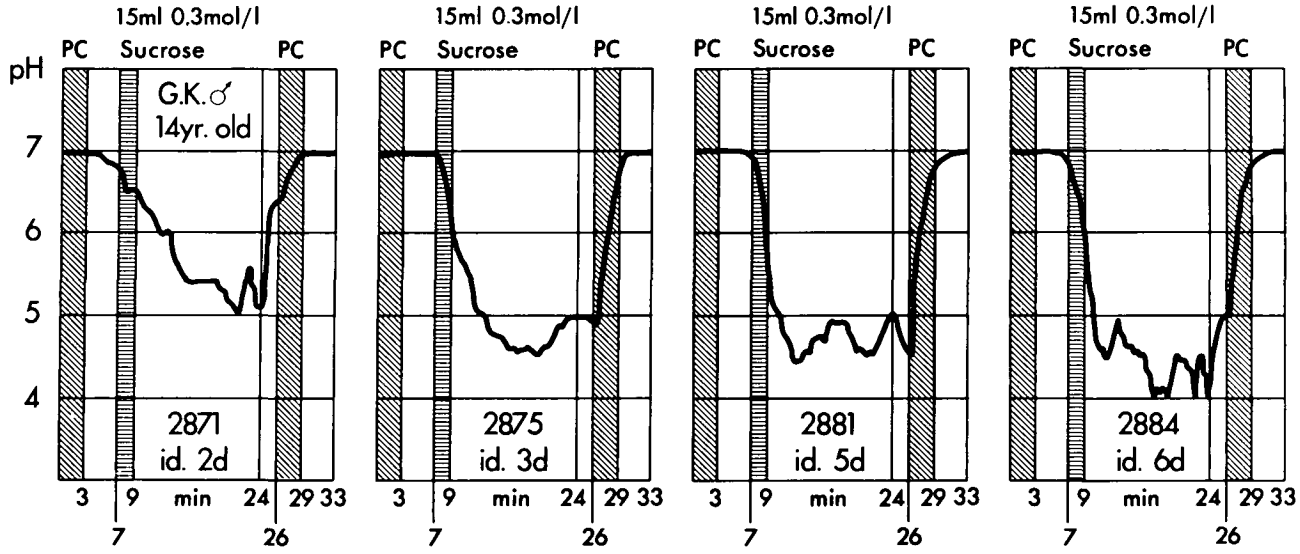

Figure 6. Telemetrically recorded pH-changes of two, three, five and six-day-old interdental plaque in a 14-year-old boy during and following 2 min. rinses with 15 ml 0.3 mol/1 (10%) sucrose solutions, PC = Paraffin chewing; d = days, age of plaque. Rate and amount of intraplaque acid formation increased along with plaque age. The results are in agreement with previous findings in adults (compare Figure 7).

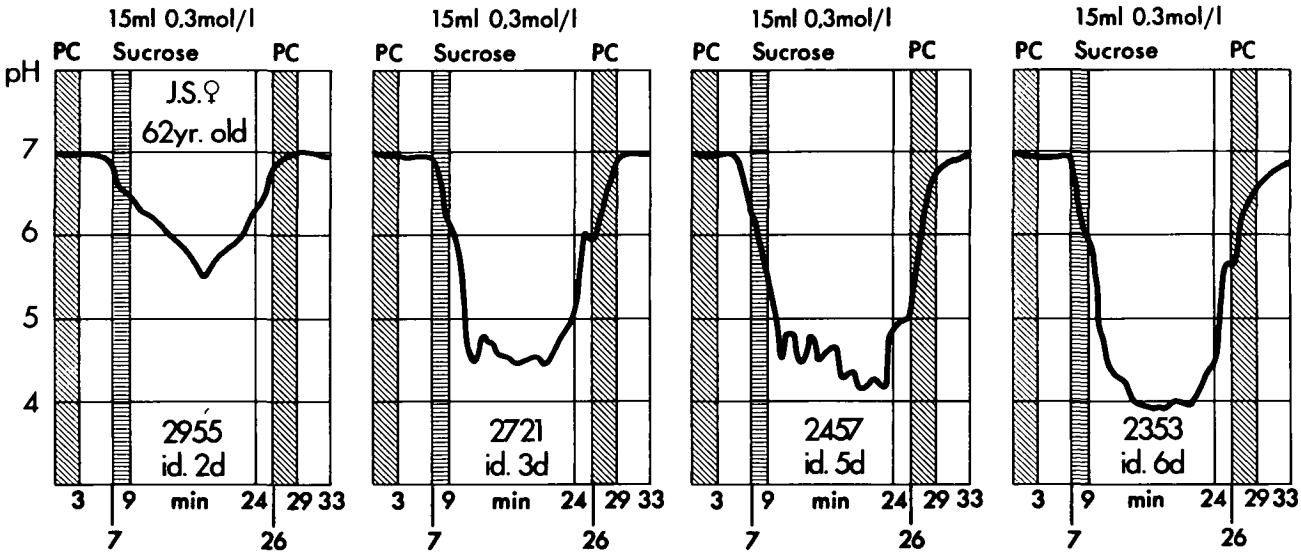

Figure 7. Telemetrically recorded pH-changes of two, three, five and six-day-old interdental plaque in a 62-year-old volunteer during and following two min. rinses with 15 ml 0.3 mol/1 (10%) sucrose solution. PC = Paraffin chewing; d = days, age of plaque. Rate and amount of intraplaque acid formation increased along with plaque age. The results are in agreement with the findings in the 14-year-old boy (compare Figure 6).

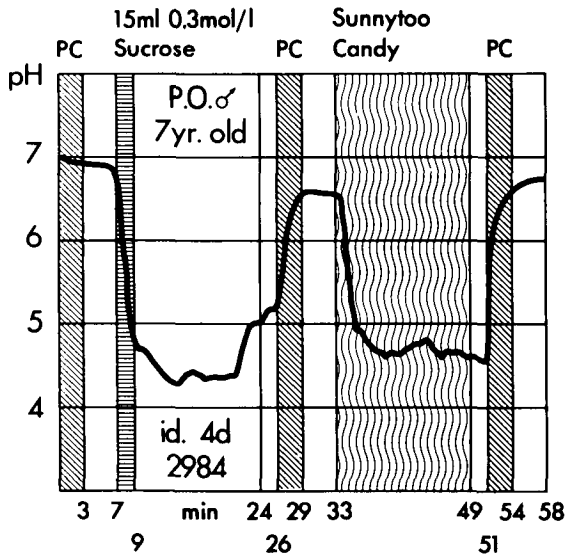

Figure 8. Telemetrically recorded pH-changes of four-day-old interdental plaque in a seven-year-old child during and following a two min. rinse with 15 ml 0.3 mol/1 (10%) sucrose solution and the sucking of a sugar containing candy (Sunnytoo*). PC = Paraffin chewing; d = days, age of plaque. Note the pronounced drop of pH to 4.3 after the sucrose rinse, and to approximately 4.5 during the 16 min. of candy sucking.

* Chocolat Succhard SA, CH-2003 Neuchâtel, Switzerland.

A great number of reports have pointed at the positive correlation between age and DMF-scores.[7,8,9,10,11] Sharp increases in the DMF scores were generally found until approximately 18 years of age followed by slower increases thereafter.

Inadequate oral hygiene certainly contributes to the high caries incidence in children. Unless supervised, oral hygiene instruction and advice were found to give unsatisfactory results.[12] Similar experiences were found in an information-motivation clinical trial on nearly 1,000 children.[13] Although the participants were seen up to six times per year, this had no significant effect on their level of information and motivation after two years.

The predominant role of sugar (sucrose) in the etiology of dental caries has been scientifically established. In a clinical study of the oral conditions in 2,000 young adults in the city of Strasbourg,[11] it was confirmed that lower socio-economic conditions are associated with higher DMF-scores. In this context, it is interesting to note that an investigation of food habits in 2,563 school children in Basel[14] revealed that children of lower socio-economic status consume significantly more sweets and confectionery between meals than their more advantaged counterparts. They also consume significantly more sweets in bed before sleep. The higher caries experience of these children

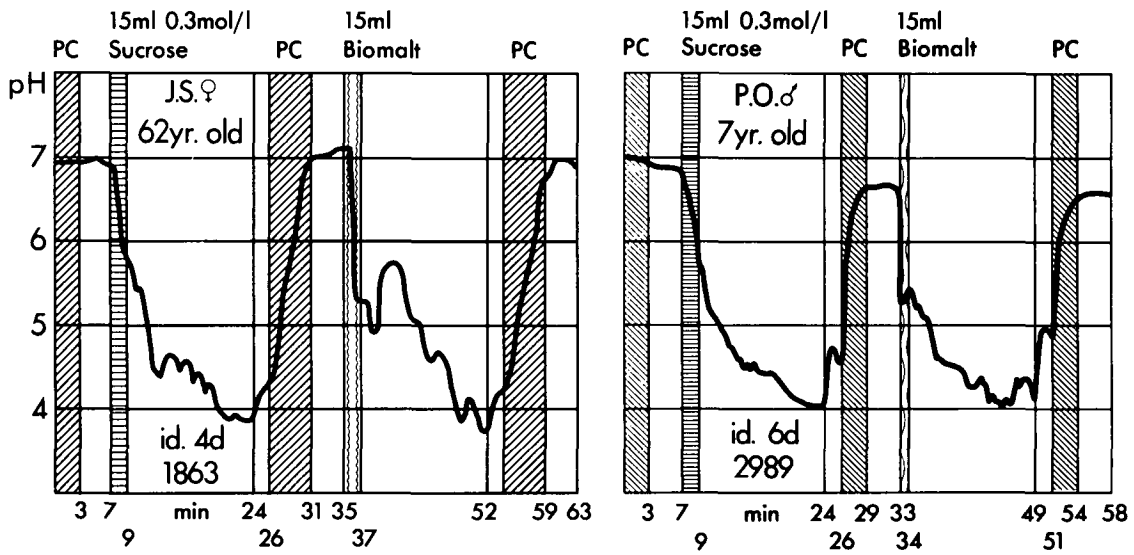

Figure 9. Telemetrically recorded pH-changes of four-day-old interdental plaque in a 62-year-old volunteer (J.S.) and of six-day-old interdental plaque in a seven-year-old boy (P.O.) during and following two min. rinses with 15 ml 0.3 mol/1 (10%) sucrose solution and the consumption of 15 ml of a health-and-fitness preparation (Biolmalt*). PC = Paraffin chewing; d = days, age of plaque. Both the sucrose rinse and the ingestion of the health-and-fitness preparation were followed by immediate pronounced and long lasting acidification of interdental plaque.

* Galactina SA, CH-3123 Belp, Switzerland.

obviously consuming more snack-type sweets has to be seen in the light of the classical Vipeholm study[15] that showed that the total amount of sugar consumed by the individual has less direct influence on caries incidence than the frequency of consumption, its form and consistency. The results from Vipeholm, with adult subjects, have since been repeatedly confirmed in children.[16,17,18] All these studies demonstrated a high, positive correlation of between-meal sugar intake and caries rate. Weiss and Trithart[17] also confirmed this with regard to def-scores in deciduous teeth. Unfortunately there are only a few studies which directly compare the sugar consumption in adults and children in the same population. In a study of snack food intake and caries development in 143 adolescents,[19] Clancy *et al.* found that the children tended to consume snack foods e.g. fruit drinks, cholocate candy, gum, and hard candy much more frequently than their mothers, 50% of whom tended not to eat many of these foods. The authors further reported negative correlations between DMFT increments and the frequency of apples, fruit juice and sugarless gum intake, and a positive association of DMFT increments with chocolate candy intake and spending money.

To plead for a considerable reduction of the total sugar consumption would be dentally desirable, but widely illusory, widely impossible and wisely forgotten since there are far too many political and economic interests involved in the sugar industry. Today the world sugar production has reached nearly 100 million tons per year and is projected to increase further.[20]

Assuming there is already adequate collective, individual and professional fluoride prophylaxis, it seems reasonable to concentrate on the reduction of sugar contained in between-and-after-meal confectionery.

In 1969, the Swiss Office of Health introduced legislation for the labelling of sweet confections and sugar-containing drugs with regard to dental health:

Confectioneries labelled "safe for teeth" (German: "zahnschonend") are products that have proved under *in vivo* conditions in man not to depress the pH of interdental plaque below 5.7 by bacterial fermentation neither during consumption nor up to 30 min. later. This critical limit is arbitrary, and, according to the Swiss regulation, only valid when plaque-pH is assessed telemetrically, thus leaving the plaque structure and diffusion characteristics undisturbed and the normal salivary influences upon plaque free from interference by the measuring method. The pH-value of 5.7 in telemetry corresponds to a pH of approximately 6.5 when measuring *in vitro* with plaque samples removed from the teeth before and after the ingestion of carbohydrates (Method of Frostell[21]).

Manufacturers are allowed to advertise their products as "safe for teeth," after submitting convincing pH-telemetric tests to the Swiss Office of Health. Labelling a product as "non-cariogenic" (German: "nicht kariogen") is only allowed when based on a long-term clinical caries incidence study. Sugar substitutes most often used for the manufacture of "safe for teeth" sweet confections are *sugar alcohols* such as non-acidogenic Xylitol, or slowly fermented (hypoacidogenic) sorbitol, mannitol, maltitol and Lycasin.® Non-nutritive *sweeteners* (saccharin and cyclamate) are often used in soft drinks and ice-creams. They may also be added to confections to enhance sweetness of sugar substitutes. The Swiss regulations for product labelling concerning dental health can be an efficient means to allow consumers to make informed choices when they select foods, snacks, beverages and drugs. This is one of the basic tenets of dietary counselling in preventive dentistry.

It is conspicuous that nearly 50% of the products tested have been evaluated on behalf of foreign manufacturers many of them from the U.S., although unfortunately none of these countries have compulsory regulations as effective as Switzerland. Is the industry more aware of the need for prevention than the health authorities of these countries?

Dental-health-minded parents, general practitioners and especially pedodontists are often placed in the awkward position of having to forbid or restrict the consumption of sweet foods and snacks by children; alternative foods that are both sweet and "safe for teeth" are certainly needed. Regulations similar to those in Switzerland might encourage the industry to produce and advertise more foods and confectionery that do not promote tooth decay.

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