INTRODUCTION

Dental caries are one of the most common infectious diseases occurred in Thai children. The prevalence of dental caries in Thai children aged 5-6 years had been reported to be 87.4% in 2000 (Ministry of Public Health, Thailand, 2002). Mutans streptococci (MS), in particular Streptococcus mutans and Streptococcus sobrinus, are considered to be closely associated with dental caries (Emilson and Krasse, 1985; Loesche, 1986). These microorganisms possess a unique combination of properties rendering them more cariogenic than other plaque bacteria. MS synthesize water-insoluble glucans from sucrose that mediate irreversible adhesion and colonization the teeth. They also produce large amounts of acid, which is involved in tooth demineralization. Another interesting property is that the acid tolerance of these kinds of bacteria is extremely high, thus allowing colonization and persistence under cariogenic conditions (Freedman et al, 1978; Tanzer et al, 1984).

Xylitol, a five-carbon natural sugar alcohol has been shown to be a successful caries preventive agent both in animals and humans (Birkhed, 1994). It is not fermented or used as a growth substrate by MS or by other microorganisms (Edwardson, 1977). Xylitol occurs in small quantities in berries and other fruits, in products made from these materials, or from other plant parts (Makinen et al, 1989). In addition, it occurs in human carbohydrate metabolism as a normal intermediate. About 5-15 g of xylitol may be formed daily in our body, mostly in the liver cells (Bassler, 1976). Xylitol has been used in Europe as a sweetener in the diabetic diets and was approved by the Food and Drug Administration (FDA) in the United States for special dietary uses in 1963 (Senti, 1986). Several studies have demonstrated that the consumption of xylitol decreased the growth and metabolism of acidogenic and aciduric oral flora and stimulated salivary defense mechanisms (Makinen, 1988). Moreover, the caries occurrence figures have been shown to decrease significantly in association with the daily use of xylitol-containing gum (Isokangas et al, 1988; 1993; Makinen et al, 1995). Two clinical field trials on the use of xylitol gum indicated that 7-10 g daily xylitol intake per child reduced the incidence of dental caries by 30-80% compared with control children who received no gum.
Therefore, the use of xylitol chewing gum is today recommended in Finland and in many other countries.

MATERIALS AND METHODS

Subjects

Approximately 250 children, aged 10-12 years, from a school in Chachoengsao Province, Thailand, were screened for salivary levels of MS. Those having \( \geq 10^5 \) CFU/ml saliva, 91 children in total, were recruited into this study. All the children were asked to maintain normal dietary and oral hygiene habits throughout the study and to refrain from the use of fluoride mouthrinse or tablets. No eating or drinking was allowed 2 hours before the appointment for specimen collection.

Chewing gum

The children were divided into 3 groups: 55% xylitol group, 100% xylitol group, and non-gum group. They were assigned to chew 2 pieces of gum for a period of 5 minutes, 3 times per day (at 8.00 AM, 11.00 AM and 3.30 PM), under the supervision of their class teachers, for 90 schooldays. Children in the 55% xylitol group received the dosage of 5.76 g/day and those in the 100% xylitol group received the dosage of 11.88 g/day.

Microbiological assay

Paraffin-stimulated whole saliva was collected by the spatula method as described by Kohler and Bratthall (1979). Plaque specimens were collected by sterile curette from supragingival plaque at the buccal surface of teeth numbered #15, #16, #35, and #36. The wet weight of the sample was determined immediately. One mg of plaque was transferred into a tube containing 5 ml reduced transport fluid. All the specimens were obtained at baseline and after 90 days and cultured for MS on Mitis-Salivarius Bacitracin (MSB) agar in 5% CO2 at 37ºC for 48 hours.

The identification of MS was based on colony morphology and Gram staining. The salivary MS score was divided into 3 categories: 1=0-20 CFU, 2=01-100 CFU, and 3 \( \geq 100 \) CFU. The amount of MS was expressed as CFU/mg plaque (wet weight).

Statistical analysis

Three groups were compared with each other at various intervals by non-parametric Kruskal-Wallis and Mann Whitney U-tests. Changes over time within a group were compared using the non-parametric Wilcoxon signed-rank test.

RESULTS

At baseline, there were no statistical significant differences between the groups in levels of salivary and dental plaque MS. The mean values of plaque MS in the three groups at baseline and at 90 days are presented in Table 1. At 90 days, statistical analysis revealed differences between the non-gum and 100% xylitol groups (\( p < 0.025 \)) and between the non-gum and 55% xylitol groups (\( p < 0.025 \)). Significant decreases in the number of MS in dental plaque was found in the 55% and 100% xylitol chewing-gum groups, compared with baseline (\( p < 0.025 \)). Although a dose response effect was not found, children in the high dose group (100% xylitol) tended to have lower plaque MS counts compared with the low dose group (55% xylitol) (3.44 ± 1.42 vs 3.96 ± 1.99).

The mean values of the salivary MS scores in the three groups at each time interval are presented in Table 2. Statistical analysis revealed significant differences between the non-gum and 100%

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Plaque level of MS (log CFU/mg plaque) at baseline and 90 days (mean ± SD).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group</td>
</tr>
<tr>
<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>Non-gum</td>
<td>30</td>
</tr>
<tr>
<td>55% xylitol</td>
<td>29</td>
</tr>
<tr>
<td>100% xylitol</td>
<td>32</td>
</tr>
</tbody>
</table>

*Statistically different from baseline (\( p<0.025 \))

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Salivary level of MS (scores) at baseline and 90 days (mean ± SD).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group</td>
</tr>
<tr>
<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>Non-gum</td>
<td>30</td>
</tr>
<tr>
<td>55% xylitol</td>
<td>29</td>
</tr>
<tr>
<td>100% xylitol</td>
<td>32</td>
</tr>
</tbody>
</table>

*Statistically different from baseline (\( p<0.025 \))
xylitol groups (p < 0.025) and between 55% and 100% xylitol groups (p < 0.025) at 90 days. No significant difference was observed between the non-gum and 55% xylitol groups (p ≥ 0.05). Chewing 100% xylitol gum caused a significant reduction in the salivary MS score (p < 0.025) but there was little change in the 55% xylitol group.

DISCUSSION

Chewing sugar-free gum has potentially beneficial effects on dental health (Edgar and Geddes, 1990). During the past 10 years, interest has been focused on using such gum after meals and snacks. Chewing resulted in the neutralization of low pH by increasing the buffer capacity of the saliva and by enhancing the clearance of fermentable carbohydrates from the oral cavity (Dodds et al., 1991). Many bacteriologic, animal, and experimental studies in man have been carried out on several sugar substitutes (Wennerholm et al., 1991). Studies evaluating the cariogenic potential of sweeteners have yielded substantial evidence that xylitol is the most promising sweetener (Makinen, 1992). The mode of action of xylitol is that it is not fermented by most dental plaque bacteria and it has an effect on two other factors that cause disease. Evidence to date indicates that the mechanisms of action of xylitol include: absence of significant degradation into acidic end-products by dental plaque, stimulation of salivary flow and increased buffering capacity, inhibition of plaque accumulation and of cariogenic bacteria, remineralization of decalcified sites and inhibition of the demineralization of sound enamel (Makinen, 1992).

Chewing gum sweetened with 100% and 55% xylitol was well accepted by all the children who were participants in this study. No adverse reactions, such as gastrointestinal discomfort or transient loose stools were reported. Our data confirm earlier observations that xylitol reduces the number of MS in dental plaque and saliva (Loesche et al., 1984; Makinen et al., 1989). Although a dose-response effect was not shown in this study, children in the 100% xylitol group tended to have lower MS counts in the dental plaque compared to the 55% xylitol group. A dose-response effect has been recently reported in a 3-week crossover study by Wennerholm et al. (1994). An increased concentration of xylitol in the gum resulted in a significant decrease in saliva MS only. In our investigation, we found a significant reduction of MS in the saliva samples of children who consumed 100% xylitol, but no significant decrease of salivary MS levels was found in the 55% xylitol group. This was not in agreement with a study by Loesche et al. (1984) which showed that the chewing of 58.8% xylitol resulted in up to a 90% reduction of MS in saliva. The difference may be because the subjects selected for our study had rather high levels of MS (≥ 10^5 CFU/ml saliva), whereas children participating in their study had ≥ 10^4 CFU/ml saliva. The time period they observed the effect was only 4 weeks, whereas our test period was 90 days. The most effective dosage used in children who were considered to be at high risk for caries was reported to be 7-10 g/day (Makinen et al., 1989). This dosage is comparable to the 100% concentration that provided 11.88 g of xylitol, whereas the use of the 55% concentration provided only 5.76 g.

Wennerholm and Emilson (1989) confirmed a significant decrease in salivary S. mutans after 2 months of chewing xylitol-containing gum, but they also found that levels of S. mutans in the saliva return to baseline values after 3 months of chewing. Longer periods of xylitol consumption did not appear to significantly decrease the number of MS in the saliva compared with a control group of non-consumers (Soderling et al., 1991) in contrast to the results obtained with short periods of use (Masalin, 1992; Loesche et al., 1984). The level of MS in plaque seem to be significantly reduced in xylitol consumers in both short- and long-term studies, regardless of original values (Soderling et al., 1991; Loesche et al., 1984). Drean and Trahan (1990) reported an increased amount of xylitol-resistant S. mutans strains in the saliva of some subjects. Such an increase has been reported in many studies (Drean and Trahan, 1990; Trahan, 1992). The authors concluded that xylitol consumption modifies the MS distribution between the dental plaque and the saliva. Regular use of xylitol along with other factors allows the xylitol-resistant mutants to be more easily shed into the saliva from the plaque than the xylitol-sensitive wild-type strains. An easier shedding of xylitol-resistant cells from the plaque, and subsequent elimination from the saliva through swal-
lowing can result in a reduction in plaque MS only, usually observed in xylitol consumers in long term studies.

In conclusion, chewing of 55% and 100% xylitol gum caused a reduction in the amount of MS in the dental plaque. However, a significant decrease of MS in saliva was observed only in 100% xylitol use. These data suggest that the use of xylitol chewing gum can be a method of caries prevention in Thai children.

REFERENCES


