RESEARCH ARTICLE

A Comparative Evaluation of Xylitol Chewing Gum and a Combination of IgY + Xylitol Chewable Tablet on Salivary Streptococcus mutans Count in Children: A Double-blind Randomized Controlled Trial

Rashi L Jain1, Sandeep Tandon2, Tripti S Rai3, Rinku Mathur4, Kamal K Soni5, Manju Rawat6

ABSTRACT

Aim: The study was designed for evaluation and comparison of the efficacy of Xylitol chewing gum and a combination of IgY + Xylitol chewable tablet (Nodacay™) against the “salivary Streptococcus mutans” count in children.

Materials and methods: About 120 children belonging to 6–12 years age—group were enrolled into this “double-blind randomized control clinical trial” according to the selection criteria. They were randomly assigned to three groups of 40 each: Group I—Xylitol chewing gum, Group II—IgY + Xylitol Chewable tablet (Nodacay™), and Group III—Control. Children in all the groups had to chew the gum/tablet twice daily for 5 minutes during the 15-day period. The salivary samples at baseline, 15 days, 1, 2, and 3 months were inoculated on mitis salivarius bacitracin agar with potassium tellurite medium and the number of colony-forming units (CFUs) of Streptococcus mutans were determined. The data obtained was subjected to statistical analysis.

Result: There was a “significant” difference in the number of “S. mutans CFUs” amongst the three groups at 15 days, 1st month, 2nd month, 3rd month with highest levels of S. mutans CFUs in Group III—Control and least in Group II—IgY + Xylitol (Nodacay™).

Conclusion: The combination of IgY + Xylitol (Nodacay™) when administered for 15 days had significant efficacy against “S. mutans” when compared to Xylitol and control group.

Clinical significance: Passive immunization with immunoglobulin Y is known not only to decrease the S. mutans count but also confers extended immunity by preventing recolonization of the tooth surface by persistence of the antibodies in saliva.

Keywords: Dental caries, Double-blind, IgY, Immunoglobulin Y, Randomized clinical trial, Streptococcus mutans, Xylitol.

International Journal of Clinical Pediatric Dentistry (2022): 10.5005/jp-journals-10005-2162

INTRODUCTION

In today’s era, dental caries is a common disease amongst children and adolescents caused by the interplay of three major factors—the host, fermentable carbohydrates, and the acid-producing bacteria. It involves decalcification of the inorganic minerals in the teeth followed by gradual dissolution of the organic matrix leading to cavitation.

Streptococcus mutans (S. mutans) is one of the most important bacterial species contributing to acid production and demineralization culminating to dental caries. Studies in literature have proven the lethal relationship between elevated proportions of S. mutans and increased incidence of dental caries. Thus, the strategy to combat dental caries would be to either eliminate this bacterium or suppress its virulence. The potential adverse effects associated with fluorides for prevention of dental caries has promoted the use of alternate treatment strategies like Xylitol chewing gums and oral passive immunotherapy using Immunoglobulin Y (IgY).

Xylitol, a sugar substitute with five carbon atoms, has been shown to drastically reduce tooth decay by decreasing the levels of S. mutans in plaque and saliva. Xylitol being nonfermentable by S. mutans is widely employed ingredient in chewing gums, tooth pastes, and oral rinses. Chewing gums containing Xylitol in addition to the above antibacterial effects also promote mechanical cleansing and salivary stimulation.

The limitations associated with parenteral caries vaccines have focused attention toward passive immunization. IgY exists in the serum of the chickens and their eggs is known as immunoglobulin egg, named for the sedimentation coefficient constant. It has similar physicochemical properties as IgY in mammals, and can help protect the immune system from infection after the immunoglobulin is introduced into the body. Water insoluble glucan is the significant constituent of the dental plaque which facilitates accumulation and aggregation of cariogenic bacteria mediated by glucan-binding proteins. The enzyme “cell
associated glucosyltransferase (CA-GTF)” of S. mutans plays a key role in synthesizing water insoluble glucan from fermentable carbohydrates present in the oral environment. IgY generated against CA-GTF causes significant reduction in recolonization of dental plaque.8 IgY not only inhibits the adhesion of microbes but also promotes agglutination and immobilization of the bacteria, enzyme inactivation and neutralization of bacterial toxins.9

Since both Xylitol and IgY are capable of decreasing the levels of S. mutans individually their combination would produce a synergistic effect against the cariogenic bacterium. Moreover, the combined efficacy Xylitol and IgY against S. mutans levels has not been tested much with clinical trials.10,11 Therefore the present study was designed to evaluate and compare the efficacy of Xylitol chewing gum (“Happydent White Xylit Chewing Gum™, Perfetti Van Melle Pvt Ltd, India)” and a combination of IgY + Xylitol chewable tablet (Nodecay™, Inzpera Healthsciences Ltd, India) in reduction of salivary S. mutans count in children aged 6–12 years by a double-blind, parallel group randomized controlled trial.

Materials and Methods

Study Design

The present study was a “double-blind, parallel group, randomized controlled trial.”

Ethical Considerations

Before initiation of the study, the corresponding institutional ethical committee reviewed and approved the protocol of the trial. A written consent stating the procedure, its possible discomfort and benefits including the presence of egg derivate in one of the study product constituted the sample size as follows:

Sample Size Determination

Sample size was determined using the formula,

\[ n = \frac{2(Z_\alpha + Z_\beta)^2 \sigma^2}{\delta^2} \]

where \( Z_\alpha \) is the z variate of alpha error that is, a constant with value 1.96, \( Z_\beta \) is the z variate of beta error that is, a constant with value 0.84."

Approximate Estimates

- 80% power
- Type I error to be 5%
- Type II error to be 20%
- True difference of at least 23,000 units between the groups
- Pooled standard deviation of 42,000”

Substituting the values gave 31 samples per group; in order to compensate for any drop-outs from the study a sample size of 40 per group was decided.

Study Subjects

Nearly 150 children were screened at the outpatient department of Pediatric and Preventive Dentistry. From this preliminary examination 120 children aged 6–12 years were enrolled into the study based on the following criteria:

Inclusion Criteria

- Children aged between 6 and 12 years of either sex.
- Children with “salivary S. mutans” level equal to or more than \( 10^5 \)” colony-forming units (CFUs),
- “Decayed-missing-filled-teeth (DMFT)” score equal to or more than 1.

Exclusion Criteria

- Children undergoing orthodontic treatment.
- Children with any congenital anomalies or intraoral prosthesis.
- Those with any systemic diseases or temporomandibular joint disorders.
- History of consuming xylitol-containing chewing gums, fluoride therapy or antimicrobial mouth rinses over the past month.
- Children who strictly avoid consumption of egg containing products.
- Children allergic to any material used in the study.

Randomization

The sequencing was generated using computerized random number table. An independent observer carried out allocation concealment by sequentially numbering the opaque containers of the study formulation according to the randomization. A second investigator allotted the study formulation to the children and gave appropriate instructions. Thus, three groups of 40 children each constituted the sample size as follows:

- Group I: Xylitol chewing gum (“Happydent White Xylit Chewing Gum™, Perfetti Van Melle Pvt Ltd, India).”
- Group II: IgY + Xylitol Chewable tablets (Nodecay™, Inzpera Healthsciences Ltd, India).
- Group III: Control Group with no intervention.

Blinding

The participants of the study were blinded to the formulation they received as the outer packaging was removed and repacked in similar looking opaque containers. In addition the primary investigator was blinded to randomization and the procedure of allotting the study formulation to the children. The primary investigator was only involved in baseline and follow-up saliva sample collection and estimation of “salivary S. mutans CFUs.”

Steps of Study

Details regarding the child’s sociodemographic status, diet, and oral hygiene practices was procured from the accompanying parent/guardian through a self-administered questionnaire.

All children in Group I (Xylitol chewing gum) were asked to chew two pellets of the gum two times a day for 5 minutes after breakfast and dinner for a period of 15 days. Children in Group II (IgY + Xylitol chewable tablet) were instructed to consume one orange chewable tablet from silver foil containing 20 mg IgY after breakfast in the morning and one white chewable tablet from blue foil with 40 mg IgY before bed at night for 15 days. They also had to avoid eating/drinking up to 1 hour after taking the tablet. Children in all the groups were instructed to brush twice daily, restrict their sugar exposures.

Saliva Sample Collection

The collection of saliva samples for determination of S. mutans levels was done as follows:

- At baseline prior to consuming the tablets,
- 15 days post-completion of Xylitol and IgY + Xylitol use and
- At the end of 1st, 2nd, and 3rd month from baseline.

The children were requested not to consume any food items or drinks an hour prior to saliva sample collection.
Efficacy of Immunoglobulin Y and Xylitol on Salivary Streptococcus mutans Levels

Microbial Analysis
One loop (1/1000th mL of salivary sample) was inoculated on the “Mitis Salivarius Bacitracin Agar with Potassium Tellurite medium (Himedia M259, India).” The plates were incubated in 5 to 10% CO2 jar at 37 °C for 48 hours. The same investigator processed and evaluated all the culture plates in order to avoid any potential bias. S. mutans appeared in pin point sized colonies as round or spherical, dark blue, and convex with rough surface. The colonies were further confirmed using various biochemical test like Gram’s staining, catalase test, mannitol and sucrose fermentation test, Arginine test, and Vogues Proskauer test. The colony count of each plate was multiplied with its dilution factor to determine the mean colony-forming units (CFUs/mL).

Statistical Procedures
Data obtained was compiled and subjected to statistical analysis using Statistical package for social sciences (SPSS v 21.0, IBM). Non-parametric test were used as the data for CFUs did not follow a normal curve as checked by Shapiro-Wilk test. Inter group comparison (>2 groups) was done using Kruskall Wallis ANOVA and pair-wise comparison using Mann Whitney U test. Intragroup comparison was done using Friedman’s (for >2 observations) and pair-wise comparison using Wilcoxon Signed rank test. Chi-square test was used to compare the frequencies of categories of variables with groups. For all the statistical tests, “p < 0.05 was considered to be statistically significant, keeping α error at 5% and β error at 20%, thus giving a power to the study as 80%.”

RESULTS
Flowchart 1 shows the stream of the participants through the study. The distribution of study population in terms of baseline characteristics as mean age and sex are mentioned in Table 1. There were no statistically significant differences on comparison of three study groups with respect to DMFT, diet, and oral hygiene practices. The S. mutans colony count on the mitis salivarius bacitracin agar plates of Group I–Xylitol (Fig. 1), Group II–IgY + Xylitol (Fig. 2), and Group III–Control (Fig. 3) at baseline, 1st month, 2nd month, and 3rd month were determined. The intergroup comparison of S. mutans CFUs/mL using Kruskal–Wallis ANOVA (Table 2) showed “no significant difference (p > 0.05)” in the S. mutans CFUs/mL between Xylitol, IgY + Xylitol, and control groups at baseline. However a “highly significant (p < 0.01)” reduction in the number of S. mutans CFUs/mL was seen in Xylitol, IgY + Xylitol, and control groups gradually over 3 months. The maximum reduction in

Flowchart 1: CONSORT flow diagram presenting the stream of patients through the study
Efficacy of Immunoglobulin Y and Xylitol on Salivary Streptococcus mutans Levels

In accordance to the last National Oral Health Survey (2002–2003) there has an alarming increase in incidence dental caries in 5–15 years age–group. This clearly indicates the challenging situation to be faced by a multitudinal country like India. Alternative modalities of preventing and treating this mammoth of a condition should be encouraged.

The American Academy Of Pediatrics recommends the consumption of chewing gums only above the age of 4 in order to

Table 1: Sample description according to the basic characteristics of the patients

| Variable                      | Group I (Xylitol) | Group II (IgY + Xylitol) | Group III (Control) | p value |
|-------------------------------|-------------------|--------------------------|---------------------|--------|
| Age                           | 8.60 ± 1.336      | 8.65 ± 1.388             | 8.85 ± 1.460        | 0.699  |
| Age                           |                    |                          |                     |        |
| Sex                           | 20                 | 20                       | 21                  | 0.967  |
| Sex                           | Male (n)           | 20                       | 20                  |        |
| Sex                           | Female (n)         | 20                       | 19                  |        |
| DMFT score                    | 1.98 ± 0.832       | 2.03 ± 0.891             | 1.90 ± 0.778        | 0.797  |
| DMFT score                    |                    |                          |                     |        |
| Frequency of cleaning teeth   | 1.50 ± 0.506       | 1.53 ± 0.506             | 1.53 ± 0.506        | 0.968  |
| Frequency of cleaning teeth   |                    |                          |                     |        |
| Frequency of sweet consumption| 2.00 ± 0.816       | 2.03 ± 0.862             | 1.93 ± 0.859        | 0.860  |
| Frequency of sweet consumption|                    |                          |                     |        |

a = non-significant difference (p > 0.05)
SD = standard deviation

Figs 1A to D: Streptococcus mutans culture of Group I–Xylitol chewing gum

number of S. mutans CFUs/mL was seen in Group II (IgY + Xylitol) and least in Group III (Control) as plotted in Figure 4. *Pair-wise comparison using Mann Whitney U test* (Table 3) showed “highly significant”*(p < 0.01) reduction in number of S. mutans CFUs/mL between IgY + Xylitol vs Xylitol, Xylitol vs Control and IgY + Xylitol vs Control at 15 days to 3 months interval. Intraclass comparison using Friedman’s test (Table 4) showed that both in Group I (Xylitol), Group II (IgY + Xylitol), and Group III (Control) there was significant reduction in the number of S. mutans CFUs/mL at 3 months interval as compared to baseline.

**Discussion**

In accordance to the last National Oral Health Survey (2002–2003) there has an alarming increase in incidence dental caries in 5–15 years age–group. This clearly indicates the challenging situation to be faced by a multitudinal country like India. Alternative modalities of preventing and treating this mammoth of a condition should be encouraged.

The American Academy Of Pediatrics recommends the consumption of chewing gums only above the age of 4 in order to
Efficacy of Immunoglobulin Y and Xylitol on Salivary *Streptococcus mutans* Levels

Figs 2A to D: *Streptococcus mutans* culture of Group II–IgY + Xylitol chewable tablet

Table 2: Intergroup comparison of *Streptococcus mutans* CFUs/mL of the three groups at various intervals

| Groups   | N  | Mean   | Standard deviation | Standard error | Median | Minimum | Maximum | Chi-square value | p value of Kruskal–Wallis ANOVA |
|----------|----|--------|--------------------|----------------|--------|---------|---------|-----------------|-------------------------------|
| Baseline | 40 | 181,700.00 | 6024.941            | 954.208        | 181,000 | 171,000 | 198,000 | 31.795          | 0.503a                        |
|          | 40 | 190,350.00 | 6911.714            | 1092.838       | 189,500 | 175,000 | 205,000 | 6911.714        |                               |
|          | 40 | 189,000.00 | 6872.465            | 1086.632       | 189,000 | 172,000 | 199,000 | 6872.465        |                               |
|          | 120| 187,016.67 | 7591.441            | 693.001        | 171,000 | 205,000 |         |                 |                               |
| 15 days  | 38 | 168,105.26 | 5853.109            | 949.500        | 170,000 | 160,000 | 180,000 | 94.588          | 0.000b                        |
|          | 38 | 150,842.11 | 7810.341            | 1267.005       | 152,000 | 133,000 | 169,000 | 7810.341        |                               |
|          | 38 | 187,078.95 | 7034.208            | 1141.099       | 186,000 | 169,000 | 197,000 | 1141.099        |                               |
|          | 114| 168,675.44 | 16,381.241          | 1534.244       | 133,000 | 157,000 | 197,000 | 1534.244        |                               |
| 1st month| 38 | 157,236.84 | 5257.860            | 852.938        | 158,000 | 150,000 | 166,000 | 150,000        | 0.000b                        |
|          | 38 | 113,052.63 | 6084.750            | 987.077        | 112,500 | 104,000 | 127,000 | 987.077         |                               |
|          | 38 | 186,710.53 | 7020.849            | 1138.932       | 186,000 | 169,000 | 197,000 | 1138.932        |                               |
|          | 114| 152,333.33 | 31,011.179          | 2904.463       | 133,000 | 150,000 | 197,000 | 2904.463        |                               |
| 2nd month| 38 | 146,263.16 | 4163.446            | 675.400        | 147,000 | 140,000 | 154,000 | 675.400         | 0.000b                        |
|          | 38 | 103,789.47 | 3898.426            | 632.408        | 104,000 | 97,000  | 112,000 | 632.408         |                               |
|          | 38 | 185,710.53 | 6476.185            | 1050.576       | 185,000 | 170,000 | 199,000 | 1050.576        |                               |
|          | 114| 145,254.39 | 33,960.365          | 3180.680       | 97,000  | 90,000  | 199,000 | 3180.680        |                               |
| 3rd month| 38 | 137,473.68 | 4150.785            | 673.346        | 138,000 | 130,000 | 146,000 | 673.346         | 0.000b                        |
|          | 38 | 99,552.63  | 2668.104            | 432.824        | 100,000 | 94,000  | 105,000 | 432.824         |                               |
|          | 38 | 185,500.00 | 5726.892            | 929.025        | 186,500 | 171,000 | 194,000 | 929.025         |                               |
|          | 114| 140,842.11 | 35,587.752          | 3333.098       | 94,000  | 90,000  | 194,000 | 3333.098        |                               |

*a* = non-significant difference (*p* > 0.05)

*b* = statistically highly significant difference (*p* < 0.01)
Efficacy of Immunoglobulin Y and Xylitol on Salivary *Streptococcus mutans* Levels

**Fig. 3:** *Streptococcus mutans* culture of Group III–Control (no intervention)

**Table 3:** Pair-wise comparisons of three study groups with respect to *Streptococcus mutans* level at baseline, 15 days, 1st month, 2nd month, and 3rd month

| Time       | Group      | Versus group  | Mann-Whitney U value | Z value | p value |
|------------|------------|---------------|----------------------|---------|---------|
| Baseline   | Xylitol    | Xylitol + IgY | 270.00               | -0.106  | 0.570a  |
|            | Xylitol    | Control       | 324.00               | -0.586  | 0.676a  |
|            | Xylitol + IgY | Control      | 735.00               | -0.627  | 0.531a  |
| 15 days    | Xylitol    | Xylitol + IgY | 50.500               | -6.984  | 0.000b  |
|            | Xylitol    | Control       | 35.500               | -7.140  | 0.000b  |
|            | Xylitol + IgY | Control      | 0.500                | -7.500  | 0.000b  |
| 1st month  | Xylitol    | Xylitol + IgY | 0.000                | -7.506  | 0.000b  |
|            | Xylitol    | Control       | 0.000                | -7.507  | 0.000b  |
|            | Xylitol + IgY | Control      | 0.000                | -7.505  | 0.000b  |
| 2nd month  | Xylitol    | Xylitol + IgY | 0.000                | -7.511  | 0.000b  |
|            | Xylitol    | Control       | 0.000                | -7.509  | 0.000b  |
|            | Xylitol + IgY | Control      | 0.000                | -7.508  | 0.000b  |
| 3rd month  | Xylitol    | Xylitol + IgY | 0.000                | -7.515  | 0.000b  |
|            | Xylitol    | Control       | 0.000                | -7.507  | 0.000b  |
|            | Xylitol + IgY | Control      | 0.000                | -7.514  | 0.000b  |

*a* = non-significant difference  
*b* = statistically highly significant difference (*p* < 0.01)
Efficacy of Immunoglobulin Y and Xylitol on Salivary Streptococcus mutans Levels

avoid the risk of choking. In accordance to the above statement, children aged 6–12 years were enrolled in all the three groups.

Chewing gums prevent tooth decay by stimulating saliva, one of the most significant host factors that determine the occurrence of dental caries. Stimulated saliva has increased acid buffering capacity because of the enhanced bicarbonate concentration thereby elevating the plaque pH. Saliva stimulated by chewing also leads to super saturation with respect to calcium and phosphorus that promotes enamel remineralization.

Previous studies by Loesche showed a significant reduction in saliva and plaque levels of S. mutans in children following administration of 5 grams Xylitol/day for 4 weeks. In the present study, the efficacy of lesser concentrations of Xylitol were evaluated, both the chewing gum (“Happydent White Xylit Chewing Gum”, Perfetti Van Melle Pvt Ltd, India) 2 pellets twice daily and the chewable tablet (Nodecay, Inzpera Healthsciences Ltd, India) two tablets per day both delivered approximately 1.6 grams Xylitol/day. In accordance to various literature studies a chewing time of 5 minutes was considered. Since the maximum beneficial effect of chewing gums is suggested after meals in the present study also children were instructed to chew the gum and the tablet after meals.

Xylitol is aptly called "magic bullet" because of the numerous studies conducted in the past which have proved its significant anti-microbial effect against salivary Mutans Streptococci.

It is nonfermentable by plaque bacteria and does not encourage bacterial growth. Xylitol neutralizes the plaque acids by production of ammonia and amino acids and promotes degradation of bacterial cell membrane by intracellular vacuole formation.

Egg yolk IgY is well suited for per-oral immunotherapy as previous study on Anti S. mutans IgY spray application in adults resulted “significant decrease” in S. mutans colonies. Tooth paste incorporated with anti S. mutans IgY lead to reduction of caries in deciduous teeth. Nguyen et al. reported that lozenges containing IgY selectively suppressed oral colonization by S. mutans. Hatta et al. evaluated that IgY rinses inhibited the adherence of S. mutans to saliva-coated hydroxyapatite discs. Thus the present study was designed for evaluation of the additive benefits of both Xylitol and IgY on salivary S. mutans levels in children.

Passive immunization against dental caries using IgY derived from chicken is financially viable as large quantities of antibodies can be obtained with sustainable availability. Also, the purification procedures such as water dilution methods are simple, cheap and nontoxic. Compared with vaccination, passive immunotherapy using IgY has distinct advantages such as: highly specific, rapid, and localized action, safeguard against inflammation by virtue of its inability to interact with human complement system, wider age range of applicability, and being nontoxic human diet.

IgY does not cause any systemic effects as it is precluded from the systemic circulation. Also as poultry eggs are a part of our routine diet, they are generally considered safe. Allergic reactions may occur upon ingestion of egg white but these can be completely avoided with IgY as it is procured from the egg yolk that is rarely associated with allergies. However for safety purpose, those children allergic to egg products were not enrolled into the study.

The results of the study showed children belonging to Xylitol group (Group I) had “significant reduction” in the proportion of S. mutans when compared to the control group. This was in accordance to studies conducted by Makinen et al., Milgrom et al., Haresa et al. However adverse effects such as diarrhea and flatulence have been reported with increased dosage of xylitol. Xylitol-resistant strains have been attributed to its extended usage. Thus, it could be assumed that apart
from their individual benefits against *S. mutans*, pairing Xylitol with IgY helped overcome these limitations. Hence, the results of the study showed after just 15 days of use, the synergistic benefit of the combination of IgY and Xylitol was evident by the maximum decrease in *S. mutans* counts in Group II (Nodecay™).

The advantage of using the combination of IgY and Xylitol (Nodecay™) was its availability in a chewable tablet form that not only cause topical release of IgY but also prevent recolonization of the tooth surface by virtue of its persistence in saliva. In the present study also, the decreased levels of *S. mutans* count in the combination group of IgY and Xylitol (Nodecay™) persisted for a period of three months beyond its interruption. Endang et al. in his animal study concluded IgY antibody incorporated in soybean milk led to reduction of *S. mutans* as well as persistence of the antibody in saliva.31

In the present study, a “no chewing gum control group” was preferred over placebo gums as they hardly cause any variations in *S. mutans* levels and also, they have a disagreeable taste posing difficulties in motivating the children to use the gums with similar frequency and duration.32,33

The limitation of the study could be a small sample size and a short follow up period. The formulation used in the present study is derived for egg yolk and many individuals prefer to follow a vegetarian or vegan diet that limits its use. Attempts could be made to harvest IgY antibodies from egg free sources to increase its acceptability among a wider population. Further studies are needed evaluating the long-term efficacy of IgY + Xylitol combination against salivary *S. mutans*.

**Conclusion**

Based on the results of the study, it could be concluded that the combination of IgY + Xylitol when administered for 15 days had a significant benefit against “salivary *S. mutans*” when compared to Xylitol and control group. Passive immunization may be initiated as early as 19 to 30 months after birth (window of infectivity) to prevent colonization of primary dentition with *S. mutans* and prevent or delay the development of caries in permanent dentition. The need of the hour is translation of scientific evidences into clinical practice with the emphasis on ecological approaches to caries prevention cause after all “an ounce of prevention is worth a pound of cure.”

**Clinical Significance**

The novel combination of IgY and Xylitol has a potential preventive approach in comparison to most of the conventional approaches that are of treatment in nature. Passive immunization with IgY not only attempts to decrease the *S. mutans* count but also confers extended immunity by preventing recolonization of the tooth surface by persistence of the antibodies in saliva.

**Manufacturer Name**

Happypdent White Xylit Chewing Gum™, Perfetti Van Melle Pvt Ltd, India. Nodecay™, Inzpera Healthsciences Ltd, India. Mitis Salivarius Bacitracin Agar with Potassium Tellurite medium (Himedia M259, India).

**Orcid**

Rashi L Jain  
https://orcid.org/0000-0002-7087-4833

**References**

1. World Health Organization. Oral Health Fact Sheet No. 318. Available at: http://www.who.int/mediacentre/factsheets/fs318/en/print.html 2007, accessed on November 9, 2010.

2. McDonald RE, Avery DR, Dean JA. Dentistry for the child and Adolescent. 10th ed. St. Louis: CV Mosby; 2016:155–176.

3. Casamassimo PS, McGtigue DJ, Fields HW, et al. Pediatric dentistry: infancy through adolescence. 5th ed. St. Louis: Elsevier; 2013:177–183.

4. Nanda J, Sachdev V, Sandhu M, et al. Correlation between dental caries experience and mutans streptococci counts using saliva and plaque as microbial risk indicators in 3–8 year old children. A cross sectional study. J Clin Exp Dent 2015;7(1):e114–e118. DOI: 10.4317/jced.51814

5. Holgerson PL, Sjöström I, Stecksen–Blicks C, et al. Dental plaque formation and salivary mutans streptococci in schoolchildren after use of xylitol–containing chewing gum. Int J Paediatr Dent 2007;17(2):79–85. DOI: 10.1111/j.1600–207x.2006.00808.x

6. Hamal KR, Burgess SC, Pevzner IV, et al. Maternal antibody transfer from dams to their egg yolks, egg whites, and chicks in meat lines of chickens. Poult Sci 2006;85(8):1364–1372. DOI: 10.1093/ps/ps6.8.1364

7. Han KJ, Shin SC. A clinical study on the influence of immunoglobulin Y-Containing chewing gum on the periodontium. Int J Clin Prev Dent 2016;12(1):37–44. DOI: 10.15236/ijpd.2016.12.137

8. Gandhimathi C, Michael A. Efficacy of oral passive immunotherapy against dental caries in humans using chicken egg yolk antibodies generated against Streptococcus mutans. Int J Pharm Bio Sci 2015;6(4):B652–B663. Available at: https://ijpbs.net.abstract.php?article=NDc0Mg==.

9. Rahman S, Van Nguyen S, Icatlo FC Jr, et al. Oral passive IgY-based immunotherapeutics: a novel solution for prevention and treatment of alimentary tract diseases. Hum Vaccin Immunother 2013;9(5):1039–1048. DOI: 10.4161/hv.23303

10. Allen JC. Sample size calculation for two independent groups: a useful rule of thumb. Proc Singapore Healthc 2011;20(2):138–140. DOI: 10.1177/20080581100802000313

11. Bali RK, Mathur VB, Talwar PP, et al. National oral health survey and fluoride mapping. An Epidemiological Study of Oral Health Problems and Estimation of Fluoride Levels in Drinking Water. New Delhi: Dental Council of India 2004. p. 67–78. Available at: https://dcindia.gov.in/Download/Books/NOHSBOOK.pdf.

12. American Academy of Pediatrics. Health Issues: Choking Prevention. What can I do to keep my child from choking? In: Caring for Your Baby and Young Child: Birth to Age 5. American Academy of Pediatrics, 2009. Available at: http://www.healthychildren.org/English/health–issues/injuries/emergencies/Pages/Choking-Prevention.aspx.

13. Thaweboon S, Thaweboon B, Soo–Amporn S. The effect of xylitol chewing gum on mutans streptococci in saliva and dental plaque. Southeast Asian J Trop Med Public Health 2004;35(4):1024–1027. PMID: 15916109.

14. Ly KA, Milgrom P, Rothen M. The potential of dental-protective chewing gum on oral health interventions. J Am Dent Assoc 2008;139(5):553–563. DOI: 10.14219/jada.archive.2008.0215

15. Loesche WJ. Role of Streptococcus mutans in human dental decay. Microbiol Rev 1986;50(4):353–380. PMID: 3540569; PMCID: PMC373078.

16. Edgar WM, Geddes DA. Chewing gum and dental health — a review. Br Dent J 1990;168(4):173–177. DOI: 10.1038/sj.bdj.4807129

17. Maguire A, Rugg-Gunn AJ. Xylitol and caries prevention—is it a magic bullet? Br Dent J 2003;194(8):429–436. DOI: 10.1038/sj.bdj.4810022

18. Aluckal E, Ankola AV. Effectiveness of xylitol and polyol chewing gum on salivary Streptococcus mutans in children: a randomized controlled trial. Indian J Dent Res 2018;29(4):445–449. DOI: 10.4103/ijdrr.IJDR_307_16

19. Chavan S, Lakshminarayan N, Kemporaj U. Effect of chewing xylitol containing and herbal chewing gums on salivary mutans streptococci count among school children. Int J Prev Med 2015;6;44. DOI: 10.4103/2008–7802.157543

DOI: 10.4171/jced.51814
Efficacy of Immunoglobulin Y and Xylitol on Salivary Streptococcus mutans Levels

20. Kumar S, Sogi SH, Indushekar KR. Comparative evaluation of the effects of xylitol and sugar-free chewing gums on salivary and dental plaque pH in children. J Indian Soc Pedod Prev Dent 2013;31(4):240–244. DOI: 10.4103/0970–4388.121822

21. Nguyen SV, Icatio FC Jr, Nakano T, et al. Anti-cell-associated glucosyltransferase immunoglobulin Y suppression of salivary mutants streptococci in healthy young adults. J Am Dent Assoc 2011;142(8):943–949. DOI: 10.14219/jada.archive.2011.0301

22. Hatta H, Tsuda K, Ozeki M, et al. Passive immunization against dental plaque formation in humans: effect of a mouth rinse containing egg yolk antibodies (IgY) specific to Streptococcus mutans. Caries Res 1997;31(4):268–274. DOI: 10.1159/000262410

23. Larsson A, Bålöw RM, Lindahl TL, et al. Chicken antibodies: taking advantage of evolution—a review. Poult Sci 1993;72(10):1807–1812. DOI: 10.3382/ps.0721807

24. Losonsky GA, Johnson JP, Winkelstein JA, et al. Oral administration of human serum immunoglobulin in immunodeficient patients with viral gastroenteritis. A pharmacokinetic and functional analysis. J Clin Invest 1985;76(6):2362–2367. DOI: 10.1172/JCI112248

25. Makinen KK, Isotupa KP, Makinen PL, et al. Six-month polyol chewing-gum programme in kindergarten-age children: a feasibility study focusing on mutants streptococci and dental plaque. Int Dent J 2005;55(2):81–88. DOI: 10.1111/j.1875–595X.2005.tb00038.x

26. Milgrom P, Ly KA, Roberts MC, et al. Mutans Streptococci dose response to xylitol chewing gum. J Dent Res 2006;85(2):177–181. DOI: 10.1177/154405910608500212

27. American Academy of Pediatric Dentistry. Policy on the use of xylitol in caries prevention. Pediatr Dent 2010;32(special issue):36–38.

28. Miyasawa-Hori H, Aizawa S, Takahashi N. Difference in the xylitol sensitivity of acid production among Streptococcus mutans strains and the biochemical mechanism. Oral Microbiol Immunol 2006;21(4):201–205. DOI: 10.1111/j.1399–302X.2006.00273.x

29. Stecksén-Blicks C, Holgersson PL, Twetman S. Effect of xylitol and xylitol-fluoride lozenges on approximal caries development in high-caries-risk children. Int J Paediatr Dent 2008;18(3):170–177. DOI: 10.1111/j.1365 -263X . 20 07.0 0 912 . x

30. Twetman S. Consistent evidence to support the use of xylitol and sorbitol-containing chewing gum to prevent dental caries. Evid Based Dent 2009;10(1):10–11. DOI: 10.1038/sj.ebd.6400626

31. Bachtiar EW, Soejoedono RD, Bachtiar BM, et al. Effects of soybean milk, chitosan, and anti Streptococcus mutans IgY in malnourished rats’ dental biofilm and the IgY persistence in saliva. Interv Med Appl Sci 2015;7(3):118–123. DOI: 10.1556/1646.7.2015.3.6

32. Autto JT. Effect of xylitol chewing gum on salivary Streptococcus mutans in preschool children. ASDC J Dent Child 2002;69(1):81–86. PMID: 12119821. Available at: https://pubmed.ncbi.nlm.nih.gov/12119821/.

33. Burt BA. The use of sorbitol– and xylitol–sweetened chewing gum in caries control. J Am Dent Assoc 2006;137(2):190–196. DOI: 10.14219/jada.archive.2006.0144