Health, 2025, 17(3), 183-191
https://www.scirp.org/journal/health
ISSN Online: 1949-5005
ISSN Print: 1949-4998

Effects of Candies on Salivary Secretion and Oral Bacterial Counts

Hiroyuki Honda[1], Yousuke Mizukami[1], Katsuaki Suzuki[1], Shigeru Watanabe[1,2*]

[1]Research & Development Department, Kasugai Confectionery Co., Ltd., Nagoya, Japan
[2]Department of Pediatric Dentistry, School of Dentistry, Asahi University, Gifu, Japan
Email: *ibishigeru@yahoo.co.jp

How to cite this paper: Honda, H., Mizukami, Y., Suzuki, K. and Watanabe, S. (2025) Effects of Candies on Salivary Secretion and Oral Bacterial Counts. *Health*, **17**, 183-191.
https://doi.org/10.4236/health.2025.173013

Received: February 20, 2025
Accepted: March 18, 2025
Published: March 21, 2025

Abstract

Purpose: Gum chewing is encouraged to alleviate symptoms of xerostomia, but few studies have been conducted with candy. We aimed to clarify the effects of sucking candies on salivary secretion and oral bacterial counts to improve the oral environment of patients with xerostomia. **Methods:** The participants' unstimulated salivary flow rate, pH, and oral bacterial counts were measured. A candy (candy stimulus 1) was then placed in the mouth, and the time for complete dissolution, the total amount of saliva secreted, and the number of oral bacteria after dissolution were measured. A second candy (candy stimulus 2) was then placed in the mouth, and the same measurements were performed. Xylicrystal Milk Mint Candies (non-sugar, Kasugai Confectionery Co., LTD) were used. Fifteen healthy adult participants were asked not to brush their teeth before bedtime on the day before the experiment. **Results:** The mean unstimulated salivary flow rate was (0.39 ± 0.29) mL/min, and the mean salivary pH was 6.96 ± 0.21. Dissolution times for candy stimuli 1 and 2 were (358 ± 62) s and (359 ± 57) s, respectively. A negative correlation ($p < 0.05$) was found between the unstimulated salivary flow rate and dissolution time for both candy stimuli. The mean candy-stimulated saliva volume and flow rates were (18.05 ± 6.75) mL and (3.07 ± 1.07) mL/min for candy stimulus 1, and (17.84 ± 6.14) mL and (3.06 ± 1.12) mL/min for candy stimulus 2. A positive correlation ($p < 0.05$) was found between unstimulated and candy-stimulated salivary flow rates. Sucking the candy significantly reduced the number of bacteria ($p < 0.05$), with candy stimulus 1 reducing bacteria to approximately 65% of the pre-sucking level and candy stimulus 2 to approximately 49%. **Conclusion:** Sucking candy increased the unstimulated salivary flow rate by approximately 7.8 times and significantly reduced the number of bacteria on the dorsum of the tongue.

Keywords

Candy, Taste Stimulation, Salivary Secretion Rate, Oral Bacteria Count, Unstimulated Salivary Flow Rate

1. Introduction

Taste stimulation is the most potent trigger of salivation, accounting for approximately 80%, while mechanical stimulation accounts for about 20% during food chewing [1]. Gum chewing has been encouraged to alleviate xerostomia symptoms, with detailed reports on types of gustatory stimuli, secretion rates induced by gum chewing, and changes in pH [2]. Habitual gum chewing improves the secretory function of the remaining salivary glands and increases the unstimulated salivary flow rate [3].

Few studies have focused on candy sucking and salivation, which are expected to stimulate salivation similarly to gum. With gum chewing, salivation decreases significantly when the taste is lost, whereas candy's effect on salivation is mainly due to taste stimulation. This stimulation is expected to continue until the candy completely dissolves in the oral cavity. Additionally, while it is difficult for elderly people to continue chewing gum after it loses its taste, candy has the advantage of not requiring chewing.

In this study, we conducted experiments to determine how effective sucking candy is in improving the oral environment of patients with xerostomia. We evaluated: 1) the amount of saliva secreted and 2) the effect of the candy on the number of bacteria in the mouth after sucking.

2. Materials and Methods

Seven healthy adult males (26 - 62 years old, average 47 years) and eight females (25 - 39 years old, average 31 years), totaling 15 participants, were included in this study. Participants with taste disorders, those currently undergoing dental treatment, those on medications such as antihypertensive drugs or tranquilizers, and those using disinfectant mouthwashes daily (e.g., chlorhexidine, povidone-iodine) were excluded. The experiment involved measuring the unstimulated salivary flow rate, pH of the collected saliva, and bacterial count immediately before the candies were placed in the mouth (before stimulus). Then, one candy was introduced (candy stimulus 1), and the time for complete dissolution (candy dissolution time 1), total saliva volume secreted during that time (candy-stimulated saliva volume 1), and number of oral bacteria (bacterial count 1) after candy dissolution were measured. The second candy was then introduced (candy stimulus 2), and the candy dissolution time (candy dissolution time 2), total saliva volume secreted (candy-stimulated saliva volume 2), and number of oral bacteria (bacterial count 2) after dissolution were measured as described for candy stimulus 1. The saliva volume per minute was calculated from the candy-stimulated saliva volumes 1 and 2 and candy dissolution times 1 and 2. Xylicrystal Milk Mint Candies (sugar-free, Kasugai Confectionery Co., LTD) were used. These candies were selected for their rich, sweet taste, preferred by elderly people, and for containing non-cariogenic sugar substitutes to prevent cavities. The experiment began at 12:00 (before lunch), and participants were instructed not to brush their teeth the night before. The experiment details were explained to the participants in advance, and their written informed consent was obtained. The Asahi University Ethics Committee approved this study (approval number: 36004).

2.1. Measurement of the Unstimulated Salivary Flow Rate and pH

For the unstimulated salivary flow rate, the participant's head was tilted slightly forward, and saliva was collected in a paper cup for 5 minutes immediately after the participant was instructed to swallow all saliva stored in the oral cavity, with nasal breathing and no tongue or lip movement [4]. The salivation rate per minute was calculated using these values. The pH of the collected saliva samples was measured using a Horiba pH meter (LAQUAtwin-pH-22B).

2.2. Measurement of Candy Dissolution Time and Total Saliva Volume Secreted during the Process

The average weight of each candy used in this experiment was (4.0 ± 0.02) g (n = 90). One candy was placed in the oral cavity and tasted until it completely dissolved and moved freely. During this period, saliva was spit into a weighed paper cup every 30 seconds.

2.3. Measurement of Oral Bacterial Count

Measurements were performed using a Panasonic bacterial counter (DU-AA01)®. Following the customary method, the center of the tongue's dorsum was rubbed with a specific cotton swab at constant pressure, inserted into the measuring device, and the oral bacterial count was measured [5].

One set of these experiments was conducted on the same day, and the second and third sets were conducted every other day after data collection, resulting in a total of three averages.

2.4. Statistical Analysis

The Student's t-test was used to test for differences in means, and Pearson's product-moment correlation coefficient was used to test for correlations between two items.

3. Results

3.1. Results on Salivary Secretion Rate and Saliva Volume

Experiments were conducted smoothly without any problems, and participants reported no discomfort or side effects from the candy. The mean unstimulated salivary flow rate of the 15 participants was (0.39 ± 0.29) mL/min (range: 0.05 -

1.15 mL/min), and the mean salivary pH was (6.96 ± 0.21) (range: 6.59 - 7.37). No correlation was found between the unstimulated salivary flow rate and pH.

The dissolution times for candy stimuli 1 and 2 were (358 ± 62) s (range: 237 - 452 s) and (359 ± 57) s (range: 243 - 450 s), respectively. Negative correlations ($r = -0.5369$, $p < 0.05$ and $r = -0.5027$, $p < 0.05$) were found between the unstimulated salivary flow rate and dissolution times of candy stimuli 1 and 2, respectively. The relationship between the unstimulated salivary flow rate and dissolution time of candy stimulus 1 is shown in Figure 1.

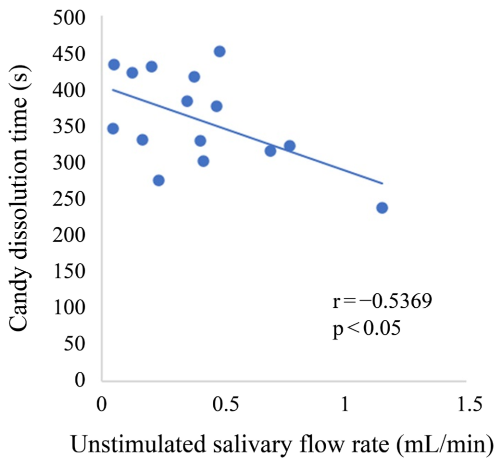

Figure 1. Correlation between the unstimulated salivary flow rate and candy dissolution time. A negative correlation ($p < 0.05$) was observed between the two.

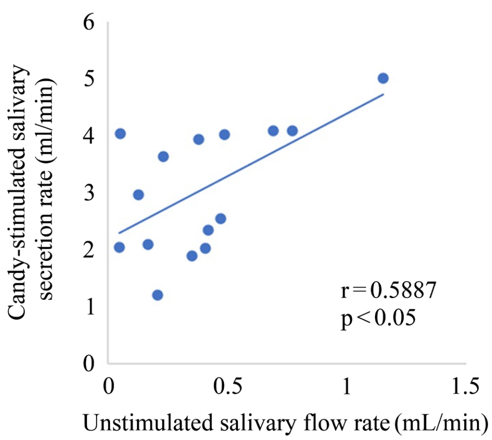

Figure 2. Correlation between unstimulated salivary flow rate and candy-stimulated salivary secretion rate 1. A positive correlation ($p < 0.05$) was observed between the two.

The mean candy-stimulated saliva volume was (18.05 ± 6.75) mL (range: 8.61 - 30.30 mL) for candy stimulus 1 and (17.84 ± 6.14) mL (range: 9.13 - 28.74 mL) for candy stimulus 2. From the dissolution time and total saliva volume, the average salivary secretion rate while holding the candy in the mouth was calculated as (3.07 ± 1.07) mL/min for candy stimulus 1 and (3.06 ± 1.12) mL/min for candy stimulus 2, both approximately 7.8 times faster than the unstimulated salivary flow rate. There was a positive correlation between the unstimulated salivary flow rate of each participant and the candy-stimulated salivary secretion rate for both candy stimuli 1 ($r = 0.5887$, $p < 0.05$) and 2 ($r = 0.6438$, $p < 0.01$).

3.2. Results on the Number of Oral Bacteria

Figure 3 shows the mean values of the pre-stimulus bacterial count, bacterial count 1, and bacterial count 2 for each participant. The results revealed significant differences between the pre-stimulus and bacterial count 1 ($p < 0.05$), pre-stimulus and bacterial count 2 ($p < 0.001$), and between bacterial count 1 and bacterial count 2 ($p < 0.05$).

When the pre-stimulus bacterial number was set at 100%, the ratios for bacterial counts 1 and 2 were 65.8 ± 37.1 and 48.7 ± 29.0, respectively. In contrast, a positive correlation ($r = 0.6447$, $p < 0.01$) was observed between the unstimulated saliva flow rate and the pre-stimulus bacterial number (Figure 4).

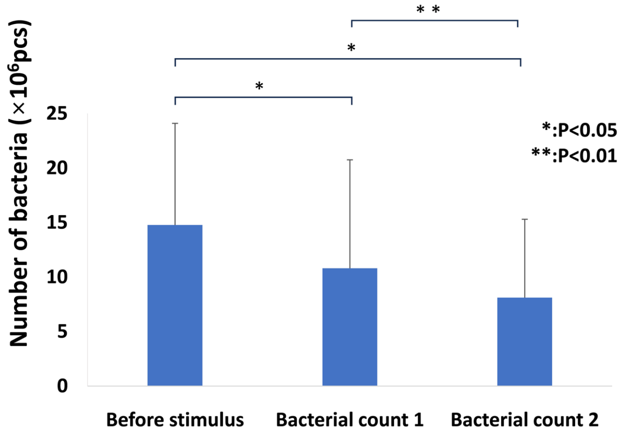

Figure 3. Comparison of averages: before stimulus, bacterial count 1, and bacterial count 2. Significant differences were found between before stimulus and bacterial count 1 ($p < 0.05$), bacterial count 1 and bacterial count 2 ($p < 0.05$), and before stimulus and bacterial count 2 ($p < 0.01$).

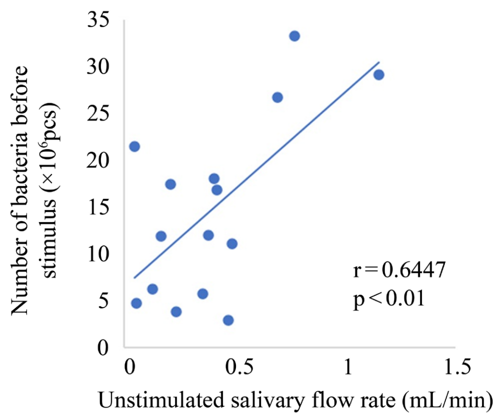

Figure 4. Correlation between unstimulated salivary flow rate and the number of bacteria before stimulus. A positive correlation ($r = 0.6447$, $p < 0.01$) was found between the unstimulated salivary flow rate and the number of bacteria before stimulus.

4. Discussion

The 2019 Vital Statistics Monthly Annual Report from Japan's Ministry of Health, Labor, and Welfare [6] states that aspiration pneumonia is the sixth leading cause of death among the elderly. Elderly people often consume many medications for their health issues, which is linked to reduced salivary secretion and a deteriorated oral environment [7]. Therefore, alongside drug use, various measures have been implemented to increase salivation rates in elderly patients with xerostomia [8].

In this context, the effect of gum chewing on salivation has attracted attention, and research has been conducted [2] [3]. However, prolonged gum chewing is often difficult to sustain, especially for older adults, and there is growing interest in using candy to supplement the benefits of gum. Although candy does not require chewing and provides sustained taste stimulation when held in the mouth, there has been little research on its effects on salivary secretion and the oral environment.

4.1. Salivary Secretion Rate

The average unstimulated salivary flow rate in the general adult population is 0.3 - 0.4 mL/min, although there are large individual differences [9]. In this study, each participant's unstimulated salivary flow rate averaged (0.39 ± 0.29) mL/min with an average salivary pH of 6.96 ± 0.21. This indicates that participants in this study had both standard flow rates and standard saliva pH.

The results showed that the dissolution time of the candies, averaging 4 g each, was approximately 6 minutes for both the first and second experiments. The average total saliva volume secreted during that time was 18.05 mL for the first candy and 17.8 mL for the second. This translates to approximately 3 mL/min, which is slightly lower than the average salivary secretion rate of 4 mL/min reported by Watanabe *et al.* [1] The act of eating may stimulate occlusal pressure and the mucous membrane due to chewing.

The saliva secreted into the oral cavity spreads in a film-like form; when a certain amount accumulates, it is physiologically swallowed [10]. During this process, some bacteria, dead bacteria, and detached mucous membranes are expelled from the oral cavity with saliva, thus maintaining a constant environment in the oral cavity [11]. The rate of salivary secretion positively correlates with the number of swallows; when the secretion rate is high, the number of swallows increases, and the oral dilution rate by saliva improves.

In the present study, saliva was collected in paper cups approximately every 30 seconds while the candy was being sucked, during which a constant amount of saliva was secreted. This may be because the candy often moves and changes its position in the oral cavity, preventing a decrease in saliva secretion due to taste adaptation [12].

4.2. Number of Oral Bacteria

Bacteria in the oral cavity adhere mainly to the teeth, tongue, and mucous membranes. Plaque on the teeth can be removed to some extent by brushing, but plaque in the grooves on the dorsum of the tongue is difficult to remove and remains for a long time. This leads to an increase in bacteria in the saliva, which is the main cause of halitosis [13]. The bacterial counter used for this measurement has been approved by the Ministry of Health, Labor, and Welfare as a general medical device covered by Japanese medical insurance since 2024. Bacteria in the liquid were collected by dielectrophoresis on an induction electrode, and changes in impedance were measured and converted to bacterial concentration (cfu/mL) in 1 mL of specimen to quantitatively measure the number of bacteria. This instrument is also used for research purposes and enables simple and quick evaluation of oral cleanliness; its measurement accuracy and reliability have been verified [14].

The study results showed that the number of bacteria on the dorsum of the tongue decreased to approximately 65% on average after one candy dissolved in the mouth and to 48.7% after the second candy dissolved. The positive correlation between unstimulated salivary flow rate and the number of bacteria just before dissolving the candy was surprising. This may be because saliva in the oral cavity flows over the dorsal surface of the tongue before being swallowed, so people with a higher volume of saliva are more likely to have bacteria on the dorsal surface of their tongue [15].

4.3. Influence on the Maintenance and Improvement of the Oral Environment of the Older Adults

The number of oral bacteria, approximately 500 species, is temporarily reduced by eating and brushing teeth for about 60 minutes a day but continues to grow every minute during the rest of the day. The cleansing action of saliva plays a major role in keeping bacterial growth below the level at which disease occurs [4]. However, for elderly patients with xerostomia (saliva secretion rate at rest is less than 0.1 mL/min) [16], maintaining adequate saliva secretion is difficult, which may lead to diseases such as dental caries, periodontal disease, halitosis, and aspiration pneumonia.

In this study, saliva secretion increased, and the number of bacteria on the dorsal surface of the tongue decreased during candy-sucking. This suggests that sucking candy three to four times a day during non-meal times may prevent the deterioration of the oral environment. The wide variety of candy flavors suggests that selecting candy with preferred tastes at different times, such as morning, afternoon, and before sleep, may effectively compensate for brushing. While candy's primary roles as a luxury food are relaxation and mood alteration, utilizing its function of maintaining a good oral environment seems to be an effective countermeasure for patients with xerostomia, common among the elderly. In the future, the effects observed in this study may be enhanced by including ingredients that promote saliva secretion in the candy.

5. Conclusion

Sucking candy increased the rate of saliva secretion by approximately 7.8 times compared to that at rest and significantly reduced the number of bacteria on the dorsum of the tongue. These results indicate that candy consumption is an effective countermeasure for elderly patients with xerostomia.

Acknowledgements

The authors thank the participants who participated in this experiment. This work was supported in part by grants-in-aid from the Ministry of Education, Science, and Culture of Japan, Grants 21K10262 (to S.W.).

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Watanabe, S. and Dawes, C. (1988) A Comparison of the Effects of Tasting and Chewing Foods on the Flow Rate of Whole Saliva in Man. *Archives of Oral Biology*, **33**, 761-764. https://doi.org/10.1016/0003-9969(88)90010-6

[2] Dawes, C. and Macpherson, L.M.D. (1992) Effects of Nine Different Chewing-Gums and Lozenges on Salivary Flow Rate and Ph. *Caries Research*, **26**, 176-182. https://doi.org/10.1159/000261439

[3] Jenkins, G.N. and Edgar, W.M. (1989) The Effect of Daily Gum-Chewing on Salivary Flow Rates in Man. *Journal of Dental Research*, **68**, 786-790. https://doi.org/10.1177/00220345890680050601

[4] Dawes, C. (1987) Physiological Factors Affecting Salivary Flow Rate, Oral Sugar Clearance, and the Sensation of Dry Mouth in Man. *Journal of Dental Research*, **66**, 648-653. https://doi.org/10.1177/00220345870660s107

[5] Hamada, R., Suehiro, J., Nakano, M., Kikutani, T. and Konishi, K. (2011) Development of Rapid Oral Bacteria Detection Apparatus Based on Dielectrophoretic Impedance Measurement Method. *IET Nanobiotechnology*, **5**, 25-31. https://doi.org/10.1049/iet-nbt.2010.0011

[6] Ministry of Health, Labor and Welfare (2019) Vital Statistics Monthly Report Annual Total (Approximate Number). https://www.mhlw.go.jp/toukei/saikin/hw/jinkou/geppo/nengai19/dl/gaikyouR1.pdf

[7] Ebihara, S. (2014) Saliva and Aspiration Pneumonia. *The Japanese Journal of Taste and Smell Research*, **21**, 61-67.

[8] Kobayashi, K., Ryu, M., Izumi, S., Ueda, T. and Sakurai, K. (2017) Effect of Oral Cleaning Using Mouthwash and a Mouth Moisturizing Gel on Bacterial Number and Moisture Level of the Tongue Surface of Older Adults Requiring Nursing Care. *Geriatrics & Gerontology International*, **17**, 116-121. https://doi.org/10.1111/ggi.12684

[9] Becks, H. and Wainwright, W.W. (1943) Rate of Flow of Resting Saliva in Healthy Individuals. *Journal of Dental Research*, **22**, 391-396.

[10] Dawes, C. (1983) A Mathematical Model of Salivary Clearance of Sugar from the Oral Cavity. *Caries Research*, **17**, 321-334. https://doi.org/10.1159/000260684

[11] Lagerlof, F. and Dawes, C. (1984) The Volume of Saliva in the Mouth before and after Swallowing. *Journal of Dental Research*, **63**, 618-621. https://doi.org/10.1177/00220345840630050201

[12] Dawes, C. and Watanabe, S. (1987) The Effect of Taste Adaptation on Salivary Flow Rate and Salivary Sugar Clearance. *Journal of Dental Research*, **66**, 740-744. https://doi.org/10.1177/00220345870660030701

[13] Ohmori, M., Miyazaki, A., Sato, H., Katano, S., Tanabe, S., Masatsuki, N., *et al.* (2005) A Study on the Effects of Tongue Cleaning. *Nihon Shishubyo Gakkai Kaishi* (*Journal of the Japanese Society of Periodontology*), **47**, 36-43. https://doi.org/10.2329/perio.47.36

[14] Oguchi, K., Oshita, N. Kishimoto, T., Kanada, Y., Fujitani, M. and Senda, A. (2013) Clinical Efficacy of Newly-Developed Device for Measuring the Bacterial Counts of Dental Plaque: Evaluation of Oral Hygiene Status. *The Japanese Journal of Conservative Dentistry*, **56**, 588-599.

[15] Watanabe, S. and Dawes, C. (1988) The Effects of Different Foods and Concentrations of Citric Acid on the Flow Rate of Whole Saliva in Man. *Archives of Oral Biology*, **33**, 1-5. https://doi.org/10.1016/0003-9969(88)90089-1

[16] Navazesh, M. (2012) Xerostomia and Salivary Gland Hypofunction; Aetiology, Diagnosis, Clinical Implications and Management. In: Edger, M., Dawes, C. and O'Mullane, D., Eds., *Saliva and Oral Health* (4*th Edition*), Thanet Press Ltd., 57-79.