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The Effect of Soft Drink Consumption on pH in Stimulated And Unstimulated Saliva

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Abstract. *Consuming soda lowers the pH of saliva due to its acid content. This decrease in pH can affect the balance of the oral cavity. Stimulated saliva has a better buffering capacity than unstimulated saliva. The purpose of this study was to determine the effect of soft drink consumption on the pH in stimulated and unstimulated saliva. This was a quasi-experimental study with a post-test only comparison group design. The study population consisted of 166 male and female students from the Dentistry Department at Prima Indonesia University. The sample size was 68 students, divided into two groups: stimulated and unstimulated saliva. The pH was measured using a digital pH meter. Data were analyzed using the Mann-Whitney test. The results showed that the average pH after soda consumption in the stimulated saliva group was* 8.03 ± 0.129*and in the unstimulated saliva group was* 5.32 ± 0.304*. The sample group that did not consume carbonated drinks had a mean saliva pH of* 6.62 ± 0.455*. The Mann-Whitney test revealed a significant difference in pH between stimulated and unstimulated saliva after carbonated drink consumption (*$p = 0.000$*;* $p < 0.05$*). In conclusion, carbonated drinks affect the pH of both stimulated and unstimulated saliva.*

Keywords: *Saliva pH; Carbonated drinks; Stimulated saliva; Unstimulated saliva; Xylitol*

INTRODUCTION

Saliva is a complex, colorless, oral exocrine fluid that contains about 99% water (Sawitri & Maulina, 2021). Saliva has an important role in the health of the oral cavity of individuals both in young and old age. The defense properties of saliva mainly lie in the rate of saliva flow, pH, and buffer capacity (Muddugangadhar et al., 2015). Saliva plays a role in supporting the digestive and swallowing processes, as well as contributing to protecting teeth from the inner and outer influences of the oral cavity. Saliva also has a very important role in maintaining the health of the oral mucosa. Attendance growth factor in saliva supports the wound healing process. The continuous flow of saliva functions to clean food residues, release epithelial cells, and remove foreign bodies. The presence of bicarbonate in saliva helps neutralize acids from food and produced by bacteria in the mouth thus contributing to the prevention of dental caries (Latifa, 2015).

Saliva pH is one of the factors that play a role in determining the acidity level in the mouth (Latifa, 2015). There are several factors that affect the pH of saliva, one of which is the food we consume. The food and drinks we consume can cause saliva to be acidic or alkaline (Sawitri & Maulina, 2021). Soft drinks are a type of drink that contains carbohydrates. Soft drinks have properties that are easily fermented, very acidic and have very high thermodynamic adhesion, so this drink is not easily eliminated by saliva (Astuti et al., 2018).

Soft drinks have a high concentration of glucose, fructose, sucrose and other sugar content (Fitriati et al., 2017). The acid and sugar content in fizzy drinks can affect the pH balance in the oral cavity, especially in saliva. Saliva pH plays an important role in maintaining healthy teeth and mouth, as pH imbalance can increase the risk of enamel demineralization and the development of dental caries (Paramanandana et al., 2020). The acidity degree (pH) of saliva under normal conditions is in the range of 6.8– 7.0 (neutral) (Sawitri & Maulina, 2021).

Based on several previous studies conducted by Andiyani, in 2020 a link was found between a decrease in saliva pH and the behavior of consuming soft drinks. There is a significant difference in saliva pH before and after consuming soft drinks (Andiriyani, 2020). Research conducted by Maulina, 2020 in Aceh stated the same thing, namely the relationship between saliva pH and the behavior of consuming soft drinks (Maulina et al., 2020).

A decrease in saliva pH can cause a disturbance of calcium and phosphate ion balance which can result in the erosion of minerals in the tooth enamel (Heymann, H.O., Swift Jr., E.J., and Ritter, 2013). Hirani's Research et al, 2021 and Pachori et al, 2018 stated that there was a decrease in saliva pH after consuming carbonated drinks. The decrease in the pH of saliva after consuming carbonated drinks is closely related to its acid content. In addition, this decrease in pH is also influenced by other components, including the proportion of carbohydrates contained in the drink (Hirani et al., 2021)(Pachori et al., 2018).

The content contained in fizzy drinks is the cause of a decrease in pH in saliva. Poor saliva pH has a high risk of dental caries. Teeth will undergo demineralization and remineralization, then if the pH is at a critical value, it causes more tooth minerals to fall out and results in caries (Prasetyo, 2005). When the pH of saliva drops below 5.5 (i.e., the critical pH value), the acid begins to break down the enamel in the teeth and the process of demineralization becomes faster than remineralization (Fitriati et al., 2017). According to Suratri et al the lower the pH of saliva, the greater the risk of teeth getting caries (Suratri et al, 2017). According to data obtained from WHO, there are at least 3.58 billion people in the world who are suspected of having dental and oral diseases, especially in cases with permanent dental caries there are at least 2.4 billion people in the world who experience it (WHO, 2018).

In Indonesia itself, according to Riskesdas, there are around 57.6% of people who have problems with dental and oral health, especially caries (Riskesdas, 2018). Many studies in India show that children in the country experience high rates of caries, which is related to low salivary pH. One study conducted by Annapoorna H. B. and Dipayan Datta noted that children with low salivary pH had twice the incidence of caries compared to those with normal pH. This is due to the high consumption of sweet and sour foods, as well as poor oral hygiene (B. & Datta, 2020).

The rate of saliva flow consists of two parts, namely the rate of stimulated and unstimulated saliva flow. The average normal value of stimulated saliva flow rate is 1-2 ml/min and unstimulated 0.29-0.41 ml/min (Rafika et al., 2019). The pH difference between stimulated and unstimulated saliva is worth noting, as stimulated saliva generally has a better buffer capacity compared to unstimulated saliva (Indriana, 2011). The buffer capacity is closely related to the pH of saliva which is able to neutralize acidic conditions in the oral cavity (Pitu Wulandari & Fellicia Lestari, 2014). Therefore, this study was conducted to find out how the consumption of soft drinks can affect the pH of stimulated and unstimulated saliva and its impact on oral health.

The problem formulation in this thesis is based on the following questions: 1) Can the consumption of soda drinks affect the pH of saliva when measured with a pH meter in stimulated saliva at the Faculty of Dentistry, Prima University? 2) Can the consumption of soda drinks affect the pH of saliva when measured with a pH meter in unstimulated saliva at the Faculty of Dentistry, Prima University?

The general objective of this research is to determine the effect of soft drink consumption on the pH of both stimulated and unstimulated saliva. The specific objectives are: 1) To examine the effect of soft drink consumption on the pH of stimulated saliva, and 2) To investigate the effect of soft drink consumption on the pH of unstimulated saliva.

The benefits of this research are as follows: For researchers, this study provides a foundation for more in-depth follow-up research in the fields of saliva, nutrition, and beverage consumption habits, and their impact on oral health. For universities, the study offers an example of applicable research that contributes to the development of science, particularly in the area of dental and oral health. For the community, the research serves as an educational tool that helps raise awareness about the impact of soft drink consumption on oral health.

The research hypothesis is as follows: Ha: There is a difference in the pH of stimulated and unstimulated saliva after consuming fizzy drinks. H0: There is no difference in the pH of stimulated and unstimulated saliva after consuming soft drinks.

MATERIALS AND METHOD

This study employed a quasi-experimental research design with a comparison group testing approach. The research was conducted at the UNPRI dental laboratory in a controlled environment during September–October 2025. The study population consisted of 166 students from the Dental Study Program at Universitas Prima Indonesia. Research subjects were selected using purposive sampling, in which participants were deliberately chosen based on specific inclusion and exclusion criteria. The inclusion criteria were Dental Faculty (FKG) UNPRI students who had been screened and signed informed consent, aged 18–25 years, cooperative, having normal salivary pH (5.6–7.0), and having no history of systemic diseases affecting saliva production.

The exclusion criteria included uncooperative subjects, those taking medications that affect saliva production, individuals with systemic diseases, and those with oral health disorders such as xerostomia (normal salivary flow rate: 0.3–0.5 mL/min unstimulated and 1.0–3.0 mL/min stimulated) or periodontal disease. The sample was divided into two groups: a stimulated saliva group, consisting of subjects who consumed fizzy drinks and chewed xylitol candy, and an unstimulated saliva group, consisting of subjects who consumed fizzy drinks without chewing xylitol candy.

The calculation of the number of samples uses the formula of two proportional sample sizes:

$$n = \frac{N}{1 + N.d^2}$$

n = Number of samples

N = Total population

d = set error rate (error level) = 0.1 or 10%

$n = \frac{166}{1+166.(0,1)^2}$

$n = \frac{166}{1+1,66}$

$n = 62,26 \approx 62$

The possibility of a drop out, the number of samples is added by 10%, then the size of the sample with the drop out correction is:

$$62 + (62 \times 10\%) = 68.2 \approx 68$$

Based on the formula above, the number of research samples used in the control group that was not given soft drinks was 34 people and the treatment group that was given soft drinks was 34 people. So, the total number of individuals needed is 68 people.

The variables in this study consisted of dependent and independent variables. The dependent variable was salivary pH, which was measured under two conditions: stimulated salivary pH, obtained after saliva stimulation in respondents who chewed xylitol candy, and unstimulated salivary pH, obtained from saliva collected at rest without stimulation. The independent variable analyzed in this study was the consumption of soft drinks. The operational definitions of all variables are provided in the attachment. The research tools used included a pH meter, saliva collection tubes, gloves, masks, a stopwatch, mouthwash, informed consent sheets, pens, pencils, and result sheets, while the research materials consisted of soft drinks, tasteless xylitol candy, and saliva samples.

Data processing and analysis were carried out through several stages. Data editing was performed to ensure the completeness and accuracy of the information and to minimize errors in the data obtained from the subjects. Coding was then conducted by converting descriptive data into numerical codes to facilitate analysis. Next, the data obtained from salivary pH measurements (stimulated and unstimulated, before and after soft drink consumption) were recorded and entered into statistical software (SPSS). Finally, tabulation was conducted by organizing the cleaned and processed data into tables according to analytical needs to simplify interpretation of the results.

Once the saliva pH data is collected, the next step is to perform a classical assumption test and a statistical test, i.e. (One, 2015):

1. Descriptive Test

   The descriptive test was used to determine the characteristics of the research variables in the form of mean values and standard deviations.

2. Normality Test

   Normality and homogeneity tests are used as a basis for determining the statistical tests to be used. The normality of data distribution was tested with the Kolmogorov Smirnov test and the Levene test. It is declared normal and homogeneous if the p value is > 0.05.

3. Mann-Whitney Test

   This test is to find out the difference in the average of two independent populations or data groups.

Research preparation began with calibrating the pH meter using pH 7 and pH 4 buffer solutions to ensure accurate measurements. Ethical procedures were then conducted, including subject screening based on inclusion and exclusion criteria and obtaining informed consent. Subjects were instructed to fast from food and drinks for two hours prior to saliva collection and were given clear explanations regarding the saliva collection procedures.

Saliva collection was performed for both control and treatment groups. In the control group, subjects were not given soft drinks, and saliva was collected immediately using the sialometry method, with subjects seated comfortably, heads slightly bowed forward, eyes open, and minimal movement, especially in the oral cavity, while spitting saliva into a tube for five minutes. In the treatment group, subjects consumed 250 ml of soft drinks, and saliva was collected using the same sialometry method under two conditions: stimulated saliva, obtained after subjects chewed tasteless xylitol candy for two minutes before saliva collection, and unstimulated saliva, obtained without xylitol chewing, with subjects spitting naturally for five minutes. Salivary pH in both control and treatment groups was measured using a calibrated Hanna digital pH meter by immersing the electrode into the saliva sample until a stable pH value appeared, after which the results were recorded for data analysis.

RESULTS AND DISCUSSION

Average pH After Consumption of Soft Drinks in Stimulated and Unstimulated Saliva

pH measurement after consumption of fizzy drinks in both stimulated and unstimulated saliva groups using a digital pH meter. The full results of the study can be seen in Table 3.1 below.

Table 1. Average pH after consumption of fizzy beverages in Stimulated and Unstimulated Saliva

Groups	Average ± Standard deviation (SD)
Treatment	6.62±0.455
Stimulated Saliva	8.03±0.129
Unstimulated saliva	5.32±0.304

Based on Table 1, the results showed that the average pH after consumption of fizzy drinks in the sample group with stimulated saliva was 8.03±0.129 and unstimulated was 5.32±0.304. The control group in the sample that did not consume soft drinks with an average saliva pH was 6.62±0.455.

Normality and Homogeneity Test

Normality test using Kolmogorov-Smirnov and homogeneity with Levene Test at pH after consumption of a fizzy beverage between stimulated and unstimulated saliva. The full results of the study can be seen in Table 2 below.

Table 2. Normality and pH Homogeneity Test Results After Consumption of Soft Drinks in Stimulated and Unstimulated Saliva

Groups	Kolmogorov-Smirnov p-value	Levene Test p-value
Stimulated Saliva	0,000	0,000
Unstimulated saliva	0,000	

Based on Table 2, the results of the study can be stated that the distributed data is abnormal and inhomogeneous ($p<0.05$). So, the data analysis used is *Mann-Whitney*.

Difference in pH After Consumption of Sparkling Drinks Between Stimulated and Unstimulated Saliva

Mann-Whitney Test analyzes the difference in pH after consumption of fizzy drinks between stimulated and unstimulated saliva. The full results of the research can be seen in Table 3 below.

Table 3. pH Difference After Consumption of Sparkling Beverages between Stimulated and Unstimulated Saliva

Treatment Groups	Average ± Standard deviation (SD)	*p-value*
Stimulated Saliva	8.03±0.129	0,000*
Unstimulated saliva	5.32±0.304	

*Significant

Based on Table 3, the results of the study can be stated that there is a significant difference in pH after fizzy drinks between stimulated saliva and unstimulated saliva ($p=0.000$; $p<0.05$). Chewing xylitol gum can increase the pH in samples that consume fizzy drinks.

The degree of acidity (pH) of saliva is one of the important factors that play a role in dental caries, periodontal disorders, and other diseases in the oral cavity (Zahara et al., 2023). The normal level of acidity (pH) of saliva in the mouth is at 7 (Astuti et al., 2021). This study aims to determine the effect of consumption of soft drinks on the pH of stimulated and unstimulated saliva.

One of the drinks that is widely loved by the public is soft drinks that contain bicarbonic acid or commonly known as carbonated drinks or fizzy drinks (Santoso et al., 2022). Commercially available fizzy drinks have a pH ranging from 2.4 to 4.7. Drinks with a low pH have the potential to damage teeth. CO2 dissolved in fizzy drinks is thought to increase acidity and lower pH (Marlina & Wijayanto, 2024). This can be seen in the results of previous research by Maulina et al., (2020) which states that there is a meaningful relationship between the consumption of fizzy drinks and the pH of saliva. The fizzier drinks are consumed, the more acidic the pH of saliva.

According to Istiqomah (2015) in Asmalinda et al., (2021), an effort to maintain the acid-base balance in the oral cavity by using a mechanical method, namely chewing. The pH of the saliva in the mouth at rest tends to be normal because there is no mechanical or chemical activity it causes. Saliva is produced at the time of eating by 90%, this process is a reaction to the stimulation of the sense of taste from chewing food. Foods that can affect salivary secretion and saliva pH in the mouth include xylitol (Suharja, 2022). Xylitol candy is a type of candy that contains natural sugar, so it is safe for dental and oral health (Zahra & Mardelita, 2025). In addition, the stability of saliva status after consumption of xylitol candy is better than that of sugary or sucrose candy (Tridiananda & Wahyuni, 2019).

The saliva pH measurement in this study was using a hanna brand digital pH meter that had previously been calibrated in a pH 7 and 4 buffer solution. Based on the results of the study, it was obtained that the average pH in the sample group that consumed soft drinks with stimulated saliva was 8.03 ± 0.129 and was not stimulated was 5.32 ± 0.304, while the control group in the sample group that did not consume soft drinks and did not stimulate it had a pH of 6.62 ± 0.455. The results of this study showed that the saliva pH was highest in the sample group of fizzy beverage consumption that chewed xylitol. The results of the research conducted by Nazri et al., (2021) stated that the saliva pH in xylitol has a higher average pH value of 7.5484 ± 0.7214, while the average pH in sucrose gum is 4.8754 ± 0.8634. Other research from Setyowati & Tiana, (2024) The average pH of saliva after consuming candy containing xylitol was obtained as 6.9844.

Chewing activities can stimulate saliva secretion. Stimulated saliva secretion causes saliva flow to become faster, thereby increasing saliva volume. The increased volume and flow of saliva is directly proportional to the increased saliva buffer capacity, which can neutralize the pH of the saliva (Asmalinda et al., 2021). This occurs because the components in saliva, namely organic and inorganic components, change (Tridiananda & Wahyuni, 2019). Saliva has three main buffers which are bicarbonate (HCO3-), phosphate (PO4+), and protein, however, the most important of the three is bicarbonate (HCO3-) (Sawitri & Maulina, 2021). Bicarbonate is an important component of the buffer system and protects by suppressing fluctuations in saliva pH (Astuti et al., 2021).

Based on the results of statistical tests Mann-Whitney In this study, it can be stated that there is a significant difference in pH after fizzy drinks between stimulated saliva and unstimulated saliva (p=0.000; p<0.05). After stimulation by chewing xylitol gum, the pH of saliva may increase. The results of this study are in line with the research conducted by Asmalinda et al., (2021) which states that there was a significant increase in the average pH value of Saliva in the treatment group. Xylitol gum has an effect on increasing saliva pH.

The results of this study are also in line with previous research by Setyowati & Tiana, (2024) It also mentions that there is an effect of chewing gum containing xylitol, namely an increase in saliva pH after chewing. Research conducted by Nurwahidah et al., (2022) It was seen that the average pH of saliva before the treatment of chewing xylitol gum was 7.2 and before it was 7.9. The paired T test obtained the results p=0.005 (p0.05) showing an increase in saliva pH before chewing xylitol candy.

Gum containing xylitol can increase the pH of saliva. Bogovska-gigova & Hristov, (2025) In the results of his research, he has concluded that the use of xylitol lollipops has been proven to have the potential to increase the pH of saliva. The difference was statistically significant compared to the baseline level (<0.001).

Chewing with xylitol candy can stimulate saliva (Nazri et al., 2021; Setyowati & Tiana, 2024; Tridiananda & Wahyuni, 2019). Increased saliva pH after chewing xylitol gum is caused by the nature and working of xylitol which cannot be fermented by oral Streptococcus and other microorganisms so that acids are not produced that can lower the pH of saliva (Nazri et al., 2021). The results of the research conducted by Cocco et al., (2020) It has been proven that cariogenic and periodontal bacteria decline after consuming xylitol candy.

Xylitol has been shown to increase the pH of saliva, thereby aiding the remineralization process. Remineralization can occur if the conditions of the oral cavity are supportive, namely sufficient calcium and phosphate levels, high pH, the right organic and inorganic matrix for crystal formation, supportive factors in saliva, and control of factors that inhibit crystal formation. One of the factors in xylitol that favors remineralization is its structure that can form complex bonds with calcium. The process of increasing the absorption of calcium to the teeth and helps the remineralization process. Calcium is surrounded by water molecules in saliva. When xylitol is consumed, there will be competition between xylitol and water molecules so that a new hydration layer is formed. This can cause calcium to stay longer in the mouth so it can be used later. Xylitol can also stabilize calcium and phosphate levels in saliva, which are important in creating ideal conditions for remineralization (Setyowati & Tiana, 2024).

CONCLUSION

The study concludes that soft drink consumption significantly alters salivary pH, with stimulated saliva exhibiting a higher average pH (8.03 ± 0.129) compared to unstimulated saliva (5.32 ± 0.304), showing a statistically significant difference ($p = 0.000$; $p < 0.05$); saliva stimulation via xylitol candy notably elevates pH in both conditions. For future research, investigators should conduct pre- and post-consumption pH measurements to assess the extent of pH decline and recovery, while also comparing xylitol candy's effects against other candies or stimulation methods to better understand buffering mechanisms and inform oral health strategies.

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