

Differences in the effectiveness of chewing pears (pyrus) and oranges (citrus sinensis) on the debris index and salivary pH: a quasi-experimental study

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ABSTRACT

Introduction: Saliva plays a crucial role in maintaining oral pH balance and influencing debris accumulation on tooth surfaces. Chewing fibrous fruits can stimulate salivary flow and provide a mechanical cleansing effect, which may contribute to changes in the debris index and salivary pH. Pears (*Pyrus*) contain catechins and dietary fiber (3.1 g per 100 g), while oranges (*Citrus sinensis*) are rich in vitamins and flavonoids that may support oral health. This study aimed to analyze the effectiveness of chewing pears and oranges on changes in the debris index and salivary pH. **Methods:** A quasi-experimental study with a two-group pretest-posttest design was conducted among 59 children aged 9–11 years at SD Negeri 39 Cakke. Participants were randomly allocated to two nearly equal groups: the pear-chewing group (n=30) and the orange-chewing group (n=29). The debris index was assessed using standard debris index criteria, and salivary pH was measured using pH paper before and after the intervention. Data were analyzed using the Wilcoxon signed-rank test and the Mann-Whitney U test, with a significance level set at $p < 0.05$. **Results:** Significant differences were observed in the mean debris index and salivary pH values before and after chewing pears and oranges ($p < 0.05$). However, no significant differences were found between the two groups regarding changes in the debris index and salivary pH ($p > 0.05$). **Conclusion:** Chewing pears and oranges demonstrated comparable effectiveness in reducing the debris index and altering salivary pH.

Keywords

salivary pH, debris index, pear (*Pyrus*), orange (*Citrus sinensis*)

Perbedaan efektivitas mengunyah buah pir (pyrus) dan buah jeruk (citrus sinensis) terhadap indeks debris dan pH saliva: studi kuasi-eksperimental

ABSTRAK

Pendahuluan: Saliva merupakan cairan mulut yang berperan penting dalam menjaga keseimbangan pH rongga mulut dan memengaruhi pembentukan debris pada permukaan gigi. Aktivitas mengunyah buah berserat dapat memengaruhi debris indeks dan pH saliva melalui rangsangan produksi saliva serta efek pembersihan mekanis. Buah pir (*Pyrus*) mengandung senyawa katekin serta serat sebesar 3,1 g per 100 g buah, sedangkan buah jeruk (*Citrus sinensis*) kaya akan vitamin dan flavonoid yang berpotensi mendukung kesehatan rongga mulut. Tujuan penelitian ini adalah untuk menganalisis perbedaan efektivitas mengunyah buah pir dan buah jeruk terhadap perubahan indeks debris dan pH saliva. **Metode:** Penelitian ini menggunakan metode kuasi-eksperimental dengan rancangan Two Group Pretest Posttest Design. Subjek penelitian adalah 59 anak usia 9–11 tahun di SD Negeri 39 Cakke yang dibagi menjadi dua kelompok, yaitu kelompok mengunyah buah pir (n=30) dan kelompok mengunyah buah jeruk (n=29). Debris indeks diukur menggunakan indeks debris, sedangkan pH saliva diukur menggunakan kertas pH sebelum dan sesudah perlakuan. Analisis statistik menggunakan uji Wilcoxon dan uji Mann-Whitney dengan nilai signifikansi $p < 0,05$. **Hasil:** Uji Wilcoxon menunjukkan terdapat perbedaan signifikan rerata debris indeks dan pH saliva sebelum dan sesudah mengunyah buah pir maupun buah jeruk ($p < 0,05$). Namun, uji Mann-Whitney menunjukkan tidak terdapat perbedaan signifikan antara kedua kelompok terhadap debris indeks dan pH saliva ($p > 0,05$). **Simpulan:** Buah pir dan buah jeruk memiliki efektivitas yang sama dalam menurunkan indeks debris dan menyebabkan perubahan pH saliva setelah dikunyah.

Kata kunci

pH Saliva, indeks debris, buah pir, buah jeruk

INTRODUCTION

Dental and oral health in Indonesia requires serious attention because a large proportion of the population suffers from dental and oral diseases. One contributing factor is the high vulnerability of school-age children to dental health problems. Poor dental and oral health can adversely affect school-age children because it can affect their nutrition, growth, and development. Teeth have important functions, including mastication (chewing), aesthetics (beauty), and phonetics (speech). The health of the oral cavity and its associated structures plays a crucial role. School age is a crucial period in children's physical growth and development.¹⁻⁷

This period is also called a critical period because at this age children begin to develop habits related to maintaining oral hygiene. School-age children are one of the groups most vulnerable to dental and oral diseases because they generally still have behaviors and habits that do not support dental and oral health. The most common dental health disorder in school-age children is tooth decay.¹⁻⁷ However, there are still some dental and oral health maintenance behaviors that are inadequate. According to the results of the 2023 Indonesian Health Survey (SKI), 97.7% of children have inadequate consumption of vegetables and fruits, and 60% of children who frequently consume sugary and processed foods.⁸

Saliva is a complex oral fluid consisting of a mixture of secretions from the major and minor salivary glands present in the oral mucosa. Saliva also affects the oral pH and debris index; if salivary flow is reduced or absent, caries will occur.⁹ Salivary pH is a measure of the hydrogen ion concentration of a solution, indicating whether the solution is acidic, alkaline, or neutral.¹⁰ Salivary pH is an important factor that plays a role in the oral cavity. For saliva to function properly, the composition and properties of saliva must be maintained in optimal balance, especially salivary pH. Salivary pH is closely related to chewing activity in the oral cavity. A decrease in salivary pH can cause rapid demineralization of tooth structures, while an increase in pH can promote bacterial colonization and increase calculus formation.¹¹

A decrease in salivary pH (acidic) and a decrease in the amount of saliva indicate an increased risk of caries. Conversely, an increase in salivary pH (alkaline) indicates an increased risk of tartar formation. Saliva plays a significant role in the prevention of halitosis, dental caries, and oral diseases overall because it protects the teeth and soft tissues in the oral cavity.¹² Saliva has a buffering capacity that plays a role in neutralizing acids produced by bacterial metabolism and maintaining the balance of enamel demineralization and remineralization. Increased salivary flow due to masticatory stimulation has been shown to accelerate the clearance of cariogenic substrates and increase the acid buffering capacity in the oral cavity. This mechanism is especially important in school-age children who still have a habit of consuming high-sugar foods and often demonstrate inadequate dental hygiene control.^{13,14}

Certain types of food consumed can affect the debris index and salivary pH. High-fiber foods, such as fruits and vegetables, play a role in influencing the debris index and salivary pH through the chewing process.¹⁵ Fruits and vegetables with a crunchy texture can naturally remove debris from teeth without damaging tooth enamel, making them effective in maintaining oral hygiene. Fresh fruits and vegetables that are high in minerals, fiber, vitamins, and water can help clean teeth by stimulating saliva production and masticatory function when chewed.

The chewing process can reduce the amount of debris on tooth surfaces. Chewing pears (*Pyrus*) can reduce the debris index value due to the fiber content in pears, thus improving oral hygiene. Pears (*Pyrus*) contain catechin compounds that reduce the adhesion of *S. mutans* bacteria in the formation of dental plaque and denature bacterial cell proteins so that the bacteria will die.¹⁶ In addition to pears, oranges (*Citrus sinensis*) are one type of fruit that contains vitamin C. In 100g of oranges there are 0.9g protein,

0.8g carbohydrates, 9.4g sugar, and 0.1g fat. Oranges are also rich in various bioactive compounds, which are believed to be effective as antioxidants responsible for the beneficial health effects.¹⁷

Pears (*Pyrus*) and oranges (*Citrus sinensis*) were selected for this study based on their specific bioactive compounds that support oral hygiene. Pears contain catechins, polyphenols with antibacterial properties against *Streptococcus mutans*, the primary bacteria responsible for plaque formation. Catechins are known to inhibit bacterial adhesion and denature bacterial cell proteins, thus inhibiting plaque formation.¹⁶ Meanwhile, pears and citrus fruits contain dietary fiber that may assist mechanical cleansing during mastication.¹⁸ Both fruits also have a fibrous texture and high water content that can stimulate saliva production and help remove food residue from the tooth surfaces through the chewing process.¹⁹ Besides being easily obtained and liked by children, the differences in chemical characteristics between relatively neutral fruits (pears) and acidic fruits (oranges) make them interesting to compare in the context of their influence on the debris index and salivary pH.^{4,20} Compared with other fibrous fruits, there has not been much research directly comparing these two fruits on oral hygiene indicators.

Besides pears (*Pyrus*) and oranges (*Citrus sinensis*) which can help clean teeth, chewing other fibrous foods such as papaya, pineapple, watermelon, apple, jicama, and red guava may also help clean teeth naturally and are readily available for fresh consumption.¹⁹ There is a comparison of the effectiveness of chewing papaya and watermelon on the debris index. Statistics show a decrease in the average debris index in the group that chewed papaya.²¹ This demonstrates the effectiveness of fibrous fruits as natural tooth cleaning agents. However, until now there has been little research directly comparing the effectiveness of pears and oranges on the debris index and salivary pH, especially in school-age children. Therefore, this study attempts to fill this gap with a controlled quasi-experimental method that combines two oral hygiene indicators simultaneously.

The novelty of this study lies in the direct comparison between pears (*Pyrus*) and oranges (*Citrus sinensis*) on two oral health parameters simultaneously, namely the debris index and salivary pH, in children aged 9–11 years. Previous studies generally evaluated fibrous fruits separately and focused only on a single oral hygiene indicator. In addition, this study compares fruits with different biochemical characteristics, where pears contain catechin compounds with antibacterial effects against *Streptococcus mutans*, while oranges are rich in vitamin C and flavonoids with antioxidant and antimicrobial properties. This approach provides new evidence regarding the effectiveness of natural fibrous fruits as simple preventive interventions for improving oral hygiene in school-age children. This study aimed to analyze the effectiveness of chewing pears and oranges on changes in the debris index and salivary pH.

METHODS

This study used a quasi-experimental method with a two-group pretest–posttest design. The selected population consisted of 80 children aged 9–11 years at SD Negeri 39 Cakke. This school was chosen because it had a sufficient number of subjects, relatively homogeneous student characteristics, and easy access and cooperation from the school, thus supporting the implementation of the research.

Sampling was carried out using a purposive sampling technique, namely the deliberate selection of subjects based on certain criteria aligned with the objectives of the research. The total sample consisted of 59 students who met the inclusion criteria, namely children aged 9–11 years, who had permanent anterior and posterior teeth, were not undergoing systemic or orthodontic treatment, did not experience oral cavity abnormalities, and were willing to participate in the entire series of study procedures with the consent of their parents or guardians. The exclusion criteria included children who

were allergic to pears or oranges, were experiencing acute systemic illness or fever, and absent during the intervention or re-measurement.

The samples were divided into two groups: the pear treatment group and the orange treatment group. The type of pear used was the green pear (*Pyrus communis* L.) variety Packham's Triumph, and the type of orange used was the sweet orange (*Citrus sinensis* L.) variety Valencia. Both fruits were purchased from the local market when ripe and suitable for consumption and prepared fresh every day. For fruit preparation: The pears and oranges were washed thoroughly, peeled, then cut into small pieces (approximately 2x2 cm) with a total weight of 100 grams per child. The fruit was not juiced and was consumed in solid form to ensure that the chewing process was maintained.

Prior to the measurements, all study subjects were instructed not to eat or drink anything other than water for at least 1 hour, and not to brush their teeth before the examination, in order to standardize the oral cavity conditions and minimize the influence of external factors on the study results. The initial examination was conducted in the morning before the study began. All subjects were asked to sit quietly for 5 minutes before the measurement to stabilize salivary conditions. Initial measurements of the debris index and salivary pH were performed before treatment. Next, subjects were asked to chew pieces of fruit according to the treatment group for 32 chewing cycles, with the same number of chews on the right and left sides of the jaw until finished, and then swallowed them as usual. After completing the chewing, the debris index and salivary pH were remeasured as post-treatment data.

The debris index measurement was performed using the Simplified Oral Hygiene Index (OHIS) with Green and Vermillion criteria, by assessing the debris score on six index teeth (16, 11, 26, 36, and 46). The debris examination was conducted by a trained and calibrated examiner who was blinded to the group allocation, while subjects were randomly assigned to the treatment groups. Calibration was performed prior to data collection through practice of examining the debris index on the test subjects until consistent examination results were obtained, ensuring that all examinations were conducted with uniform and reliable procedures throughout the study. Salivary pH was measured using universal litmus paper pH strips. Unstimulated saliva was collected in an amount of approximately 2 ml by spitting into a sterile container. The strip was dipped for 10 seconds, then compared with the standard color scale within 30 seconds.

The data collected in this study were primary data obtained through purposive sampling. Data processing was carried out using computerized methods and analyzed using SPSS version 29. Statistical analysis was performed to assess changes in the debris index and salivary pH before and after treatment and to compare effectiveness between groups. The Wilcoxon test was used to analyze differences in the debris index and salivary pH before and after treatment in each group, while the Mann-Whitney U test was used to analyze differences between the pear chewing group and the orange chewing group. The significance value was set at $p < 0.05$.

RESULTS

This study aimed to analyze the differences in the effectiveness of chewing pears (*Pyrus*) and oranges (*Citrus sinensis*) on changes in the debris index and salivary pH in children aged 9-11 years. A total of 59 subjects who met the inclusion and exclusion criteria were randomly divided into two treatment groups. Group allocation was carried out using simple randomization through drawing subject numbers so that each subject had an equal chance of being included in either the pear (*Pyrus*) chewing group or the orange (*Citrus sinensis*) chewing group. Each subject was measured before and after treatment. Statistical analysis used the Wilcoxon test to analyze differences within groups and the Mann-Whitney test for comparisons between groups.

Table 1. Differences in the Mean Debris Index (DI) Before and After Chewing Pears (Pyrus) and Oranges (Citrus sinensis)

Treatment Group	Mean Before	Mean After	<i>p-value</i>	Difference	<i>p-value</i>
Pear	1.18	0.67	0.001 a	0.51	
Citrus fruit	1.26	0.74	0.001 a	0.52	0.32 b

Table 1 shows that both pears and oranges significantly reduced the debris index after chewing ($p < 0.05$). However, there was no significant difference in effectiveness between the two fruits in reducing the debris index ($p = 0.32$).

Table 2. Mean salivary pH before and after chewing pears (Pyrus) and oranges (Citrus sinensis)

Treatment Group	Mean Before	Mean After	<i>p-value</i>	Difference	<i>p-value</i>
Pear	7.37	6.71	0.001 a	0.66	
Citrus fruit	7.34	6.54	0.001 a	0.8	0.26 b

Table 2 shows a significant decrease in salivary pH after chewing pears and oranges ($p < 0.05$). However, no significant difference was found in the magnitude of pH reduction between the two fruit groups ($p = 0.26$).

DISCUSSION

Table 1 shows that both the pear and orange chewing groups experienced a decrease in the average debris index. The pear group showed a decrease of 0.51, while the orange group experienced a decrease of 0.52. Analysis using the Wilcoxon test showed that the decrease in each group was statistically significant. However, the Mann-Whitney test showed no significant difference between the two treatments ($p = 0.32$). These results indicate that both types of fruit are comparably effective in reducing debris accumulation on tooth surfaces.

Similar results were obtained in salivary pH measurements as shown in Table 2, where the pear group experienced a mean decrease in pH from 7.37 to 6.71 and the orange group from 7.34 to 6.54. Although a greater mean decrease was found in the orange group compared with the pear group, no significant difference was found between the two groups ($p = 0.26$). This decrease in salivary pH may be associated with the natural organic acid content in the fruit, which can stimulate salivary secretion and modulate salivary pH. Although salivary pH decreased after fruit consumption, the pH value in this study did not reach the critical limit for enamel demineralization ($pH < 5.5$). Recent literature suggests that the decrease in pH caused by fresh fruit consumption is temporary and generally returns to basal conditions within 20–30 minutes through salivary buffering mechanisms. Therefore, consuming whole fruit through the chewing process is considered relatively safe compared with fruit juice, which results in longer acid exposure.^{22,23}

Physiologically, these results reinforce the role of high-fiber fruits in stimulating the natural cleansing mechanisms of the oral cavity. In addition to their bioactive compounds, pears and citrus fruits are also rich in natural dietary fiber. A study conducted by Slavin found that pears contain approximately 5.5–6 grams of fiber per 100 grams of fruit, with a dominant proportion of insoluble fiber. This fiber content is higher than that of some other fruits, such as apples or guavas.²⁴ Meanwhile, research by Dhillon et al. found that citrus fruits are rich in soluble fiber, such as pectin, which accounts for 60–70% of the total fiber. This soluble fiber has the ability to absorb water, increase saliva viscosity, and help clean tooth surfaces during chewing.²⁵ Chewing pears and oranges reduces the debris index through two main mechanisms: mechanical and chemical. Mechanically, the fruit's

coarse fiber content rubs directly against tooth surfaces during chewing, helping to remove soft debris or plaque adhering to the teeth, with an effect similar to light brushing. In addition, chemically, pears contain catechins, which have antibacterial activity against *Streptococcus mutans* by inhibiting bacterial adhesion and denaturing bacterial cell proteins, thereby inhibiting plaque formation. Meanwhile, oranges contain naringin and hesperidin, which act as antimicrobials and antioxidants, thus inhibiting the growth of pathogenic bacteria in the oral cavity.^{18,26,27}

Research by Hidayanti,¹⁹ states that consuming fibrous fruits such as apples and red guava can reduce the accumulation of debris on tooth surfaces through the chewing process. Research by Molek et al.,¹⁶ also states that pears contain catechins, polyphenolic compounds that have antibacterial effects through denaturing bacterial proteins. Meanwhile, research by Baghurst,¹⁸ explains that citrus fruits contain flavonoids such as naringin and hesperidin, which have the ability to inhibit the growth of pathogenic microorganisms in the oral cavity. The presence of these bioactive compounds may inhibit plaque formation and improve the condition of the oral microflora. Recent studies have shown that consuming fresh fruit with a crunchy texture can temporarily reduce plaque scores through a combination of mechanical effects and increased reflex saliva secretion.^{28,29} In addition, polyphenols in pears and citrus flavonoids in oranges have been reported to exert anti-adhesion effects against *Streptococcus mutans*, thereby inhibiting the formation of dental biofilms in vitro. These findings strengthen the biological basis for selecting these two fruits in this study.^{30,31}

The decrease in salivary pH is also in line with research by Janah,²⁰ which shows that fruit juice with high vitamin C content can reduce salivary pH by increasing the viscosity of oral fluids. However, a decrease in salivary pH below the critical threshold (pH <5.5) can negatively impact oral health by causing enamel demineralization and promoting caries formation. Therefore, while vitamin C is beneficial, the form and frequency of consumption should still be considered to maintain a balanced oral environment. Research by Arini et al.,⁴ also shows that consuming fruits with high vitamin C and acid content, such as strawberries and oranges, can lower salivary pH due to a temporary increase in the production of thin saliva.

Differences in chemical characteristics such as organic acid concentration, water volume, and fiber type in pears and oranges may be the reason why no significant differences were found between treatment groups. Children aged 9–11 years are in the final phase of mixed dentition, characterized by the presence of newly erupted posterior permanent teeth and being more susceptible to plaque accumulation due to deep pit and fissure morphology. Simple interventions involving the consumption of fibrous fruits that are easily accepted by children can be an additional promotive-preventive strategy in school dental health programs.³² These findings are also in line with global recommendations that emphasize a population-based preventive approach in school children to reduce caries prevalence.³³

This study has several limitations in terms of methodology. Measurement of salivary pH using litmus paper provides only an approximate pH range and have lower accuracy than digital pH meters, so results may be less precise. Furthermore, variables such as basal saliva volume and toothbrushing habits are not systematically recorded, potentially affecting the results of debris index and pH measurements. The study was also conducted only in the short term and at one elementary school location, so the generalizability of the results is limited.

Future research should use digital pH meters to improve data accuracy and involve long-term observation to determine the lasting effects of fruit consumption on oral hygiene. It is also necessary to expand the study population and diversify the types of fruit used so that the research results can be applied more widely. Using a control group and adding other variables such as plaque or gingivitis index may also provide more comprehensive results.

CONCLUSION

Pears and oranges were equally effective in helping clean teeth and reduce salivary pH after chewing, with no significant differences between the two. These results suggest that both fruits may serve as natural and safe options for supporting oral hygiene. The implication of this research is that consuming fibrous fruits like pears and oranges can be an alternative way to support healthy dental habits, especially in children, without relying entirely on chemical products.

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Institutional Review Board Statement:

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