DIFFERENCES IN pH VALUE AND SALIVARY FLOW RATE BEFORE AND AFTER CHEWING GRAPES COMPARED WITH STRAWBERRY

(PERBEDAAN NILAI pH DAN LAJU ALIR SALIVA SEBELUM DAN SETELAH MENGUNYAH BUAH ANGGUR DIBANDINGKAN DENGAN BUAH STROBERI)

Herryawan [1*], Euis Reni Yuslianti [2], Maghfira F. Febriani[1]

[1]Departments of Periodontic, Faculty of Dentistry, Universitas Jenderal Achmad Yani, Cimahi, Indonesia

[2]Department of Oral Biology, Faculty of Dentistry, Universitas Jenderal Achmad Yani, Cimahi, Indonesia

*Corresponding author

herryawan@lecture.unjani.ac.id

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ABSTRACT

The pH value and salivary flow rate are important factors in maintaining the balance of the oral cavity and affect the health of the teeth and mouth. When we chew foods high in water, fibre, and vitamin C, such as grapes (*Vitis vinifera*) and strawberries (*Fragaria x ananassa*), the value of these two elements can change due to stimulation. This study aims to evaluate pH levels and salivary flow rate fluctuation before and after chewing grapes in contrast to strawberries. The research method was a quasi-experimental study; forty-two research participants from Faculty of Dentistry, Universitas Jenderal Achmad Yani students. They were divided into two groups: grape and strawberries. The experiment was

divided into two parts: before and after chewing the fruit. The salivary flow rate was assessed through visual screening, and salivary pH was measured using a pH meter. Data were analyzed by t-test ($p<0.05$). The result shows that the mean pH value and salivary flow rate increased after chewing grapes and strawberries. Compared with before chewing fruit, this increase was statistically different ($p=0.000$) in the two groups. Meanwhile, when the mean difference was insignificant. Chewing fruit that contains water, fibre, vitamin C, and a sour taste can increase salivary secretion, which follows the buffer system to increase salivary pH.

Keywords: chewing grapes; chewing strawberries; salivary flow rate

ABSTRAK

Nilai pH dan laju aliran saliva merupakan faktor penting dalam menjaga keseimbangan rongga mulut dan berpengaruh terhadap kesehatan gigi dan mulut. Saat kita mengunyah makanan tinggi air, serat, dan vitamin C, seperti anggur (Vitis vinifera) dan stroberi (Fragaria x ananassa), nilai kedua unsur ini dapat berubah karena adanya rangsangan. Penelitian ini bertujuan untuk mengukur bagaimana tingkat pH dan laju aliran saliva berfluktuasi sebelum dan sesudah mengunyah anggur dengan stroberi. Empat puluh dua peserta penelitian dari mahasiswa Kedokteran Gigi Universitas Jenderal Achmad Yani mengikuti penelitian eksperimen semu. Mereka dibagi menjadi dua kelompok, yaitu kelompok anggur dan kelompok stroberi. Percobaan dibagi menjadi dua bagian: sebelum dan sesudah mengunyah buah. Laju aliran saliva dinilai melalui skrining visual, dan pH saliva diukur menggunakan pH meter. Hasil penelitian menunjukkan bahwa rerata nilai pH dan laju aliran saliva meningkat setelah mengunyah anggur dan stroberi. Dibandingkan dengan sebelum mengunyah buah, kenaikan ini berbeda secara statistik (p=0,000) pada kedua kelompok. Sementara itu, ketika perbedaan rerata untuk kedua

parameter dibandingkan antara kedua kelompok, perbedaannya adalah tidak signifikan dengan nilai pH (p=0,860) dan laju aliran saliva (p=0,810). Mengunyah buah yang mengandung air, serat, vitamin C, dan rasa asam dapat meningkatkan sekresi saliva, yang sesuai dengan sistem buffer untuk meningkatkan pH saliva.

Kata kunci: *laju alir saliva; mengunyah apel;mengunyah stroberi*

INTRODUCTION

Dental and oral health are essential aspects of general health that can affect a person's quality of life. So it must be considered in a country's population development. A clean and healthy oral cavity will keep teeth and mouth free from disease. According to the National Basic Health Research (Basic Health Research-Riskesdas 2018), 57.6% of Indonesians experienced problems with their teeth and mouth. This figure is higher than the 25.9% reported in Riskesdas in 2013 and shows that Indonesia's prevalence of dental and oral diseases is still very high.[1-4]

Dental and oral diseases are caries and periodontal such as gingivitis and periodontitis. Plaque accumulation is the leading cause of both diseases and is closely related to poor oral hygiene conditions. Dental plaque is a collection of bacteria with an elastic structure that clinically appears in the form of soft yellow-grey deposits and is firmly attached to hard surfaces in the oral cavity. Maximum elimination of dental plaque is essential and is the key to successfully treating these diseases because it can inhibit the attachment of plaque bacteria to the teeth.[3-5] Plaque elimination, also known as plaque control, can be done by several mechanically or chemically methods. Brushing teeth, either manually or electrically, is a mechanical method believed to be essential in plaque control efforts. This activity should be done at least twice daily with the proper technique and the correct method. Research by Wiradona et al. in 2013 reported that brushing teeth using good and appropriate techniques and methods proved to reduce plaque accumulation. Routine use of assistive devices such as interdental brushes and dental floss under certain conditions is also sometimes suggested as an additional method of mechanical plaque control. Gargling with mouthwash is an example of a chemical plaque control effort. It indicates

support for mechanical plaque control efforts. The mouthwash contains beneficial compounds that help eliminate plaque or inhibit plaque formation. Research conducted by Arora et al. in 2014 showed that mouthwash as an additional method of plaque control could provide more effective results in reducing the amount of plaque accumulation.[5-9] Other methods can be alternatives in carrying out plaque control efforts. These methods combine the two methods (mechanical and chemical) carried out simultaneously. Eating foods containing lots of fibre and water, such as grapes and strawberries, is an example of this method. When consuming these two fruits, the chewing process will increase the salivary flow rate, which, together with the fibre and water content, can help self-cleansing for cleaning the oral cavity. An increased salivary flow rate can also increase the pH of saliva. The buffering capacity of saliva will also increase and help neutralize plaque acids that cause caries and gingivitis.[11-12]

Red grapes (*Vitis vinifera*) have many ingredients that the body's system can utilize. Previous research conducted by Kurniawan in 2018 reported that grapefruit-infused water contains many tannins, increasing plaque pH and saliva pH. Indonesian strawberry (*Fragaria x ananassa*) has a sour taste that can stimulate salivary secretion, causing the salivary viscosity to become waterier and increasing the salivary flow rate. Previous research conducted by Arini et al. in 2016 also reported increased salivary pH after chewing strawberries. Strawberries have higher levels of vitamin C than grapes, so they have a sourer taste. Vitamin C, by its chemical name ascorbic acid, is chemically acidic. Vitamin C generally has an acidity level (pH) of about 2 to 4. The pH value ranges from 1 to 15, where a pH value of 7 is the middle number indicating that a substance is neutral. The lower the pH value, the more acidic a substance is.. [13-17]

METHOD

The design of this study used a quasi-experimental method. Sampling was done by consecutive sampling, with the number of samples obtained as many as 42 people divided into two groups, each totalling 21 people. The sample is an active student of Faculty of Dentistry Unjani who has a complete number of teeth and has agreed according to the informed consent form. They were not fasting on the day of the study. They were also not taking six kinds of medications such as analgesics, anticonvulsants, antihistamines, and antihypertensives, not currently undergoing radioactive radiation therapy, not using orthodontic appliances, both removable and fixed, and not having a habit of drinking

alcoholic beverages.[19-21]

The research used authorization from the Health Research Ethics Commission, Faculty of Medicine, Universitas Jenderal Achmad Yani, with the number: 006/UM1.01/2020. The tools and materials used for this research are approval and inspection forms, stationery, trays, digital scales, masks and gloves, Lutron™ pH meter, saliva collection glasses, a stopwatch, 100 grams of grapes of the Prabu Bestari variety, and 100 grams of strawberries.[22]

All study subjects were instructed not to eat or drink for 90 minutes before the study. One group chewed grapes, while the other chewed strawberries, each weighing 100 grams, 32 times for 10 minutes. The salivary flow rate used the visual screening method. The patient's lower lip was pulled and rubbed using sterile gauze on the labial surface until it was dry, and then the salivary flow rate was immediately observed for one minute. Pay attention to the second when saliva appears in that area. The salivary pH value was carried out after examining the salivary flow rate. Patients collected saliva in the oral cavity for five minutes. Then the saliva was put in a measuring cup and measured using a pH meter. The data obtained from the examination results were then processed and analyzed using paired and unpaired T-tests. Paired T-test is a statistical test used to see whether there are differences in pH values and salivary flow rates before and after chewing grapes and strawberries. In contrast, the unpaired T-test whether there are differences between the two groups regarding the mean pH values and salivary flow rate before and after chewing grapes compared to strawberries.[22-23]

RESULT

Chewing grapes

The difference in the mean pH value of saliva before and after chewing grapes is shown in Table 1.

Table 1. The difference in the mean pH value of saliva before and after chewing grapes

Before	After	Mean Difference	P-Value
7.25	7.44	0.19	0.000*

*) Significant paired T-test

The difference in the mean pH value of saliva before and after chewing grapes was 0.19 (p=0.000), which means that chewing grapes can significantly increase the pH value of saliva.

The difference in the mean salivary flow rate before and after chewing grapes is shown in Table 2.

Table 2. The difference in the mean salivary flow rate (in seconds) before and

after chewing grapes

Before	After	Mean Difference	P-Value
52.81	25.92	26.89	0.000*

*) Significant paired T-test

The difference in the mean salivary flow rate before and after chewing grapes was 26.89 seconds (p=0.000) which means that chewing grapes can significantly increase the salivary flow rate.

Chewing strawberry

The difference in the mean pH value of saliva before and after chewing strawberries is shown in Table 3.

Table 3. The difference in the mean pH value of saliva before and after chewing strawberry

Before	After	Mean Difference	P-Value
7.19	7.41	0.22	0.000*

*) Significant paired T-test

The difference in the mean pH value of saliva before and after chewing strawberries was 0.22 (p=0.000), which means that chewing strawberries can significantly increase the pH value of saliva.

The difference in the mean salivary flow rate before and after chewing strawberries is shown in Table 4.

Table 4. The difference in the mean salivary flow rate (in seconds) before and after chewing strawberry

Before	After	Mean Difference	P-Value
45.18	19.08	26.10	0.000*

*) Significant paired T-test

The difference in the mean salivary flow rate before and after chewing strawberries was 26.10 seconds (p=0.000) which means that chewing grapes can significantly increase the salivary flow rate.

Comparison of a grape group with a strawberry group

Mean pH values comparison before and after chewing grapes with before and after chewing strawberries is shown in Table 5 below:

Table 5. The comparison of the mean pH value before and after chewing grapes with before and after chewing strawberries

Grapes	Strawberry	P Value
0.19	0.22	0.860**

**) Not significant, unpaired T-test

The table above shows that comparing pH values before and after chewing grapes with before and after strawberries was insignificant between the two groups (p=0.860).

Salivary flow comparison rate before and after chewing grapes with before and after chewing strawberries is shown in

table 6 below:

Table 6. Salivary flow rate (in seconds) comparison before and after chewing grapes with before and after chewing strawberries

Salivary flow rate (s) **Grapes**	Salivary flow rate(s) **Strawberry**	**P Value**
27.67	26.10	0.810**

**) Not significant, unpaired T-test

The table above shows that comparing salivary flow rates before and after chewing grapes with before and after strawberries was insignificant between the two groups (p=0.810).

DISCUSSION

Based on the results of this study, the pH value and salivary flow rate after chewing grapes increased significantly compared to the pH and salivary flow rate before chewing grapes. The increase in pH value and salivary flow rate after chewing grapes maintain a balance in the oral cavity condition with an average pH and salivary flow rate. Typical pH values and salivary flow rates are ideal conditions to avoid dental and periodontal diseases and improve dental and oral health. Grapes contain several phytochemicals, such as catechins and tannins, which have antibacterial properties for protective functions. The antibacterial properties of catechins and tannins are effective in inhibiting plaque-causing bacteria.[24-29]

This result is in line with research by Gloria et al. (2019) and Jannata et al. (2014) that catechins and tannins have antibacterial properties that are effective in inhibiting S. mutans bacteria. The antibacterial properties of tannins work by inhibiting the bacterial glucosyltransferase enzyme and disrupting the integrity of the bacterial cell membrane that causes plaque. Later, bacterial proteins become lysed, and the formation of dental plaque is inhibited. Catechins are bioflavonoids that function as antioxidants and antibacterial. The action of catechins is to inhibit the formation of dental plaque by denaturing bacterial proteins using phenolic compounds contained in catechins. Phenol is toxic to bacteria, which causes the bacterial protein's three-dimensional structure to be exposed, causing the biological activity of bacteria to be damaged. The decrease in the growth of dental plaque bacteria due to several antibacterial phytochemical compounds can maintain the acid-base balance of the oral cavity so that it can increase the pH of saliva in the oral cavity.[15,24-29] In addition, tannins have an astringent or bitter taste that stimulates the tongue's taste buds. Later, the buds formed nerve impulses transmitted to the brain stem through the tractus solitaries.

The inferior and superior salivatory nuclei transmit signals to the submandibular gland, sublingual, and parotid. It helps secrete saliva. The increase in salivary secretion is directly proportional to the rise in the content of bicarbonate, phosphate, and calcium ions, and this can cause the salivary pH to increase.[30,31]

In the group that chewed strawberries, there was also a significant increase in the pH value and salivary flow rate compared to before chewing strawberries. The results of this study follow the research conducted by Arini DS et al. in 2016 regarding the effect of chewing strawberries on changes in salivary pH which increased accompanied by a decrease in plaque formation and the index of debris in the oral cavity.[14] Strawberries contain fibre, water, vitamin C, and a sour taste that can stimulate the taste buds to signal the brain to secrete saliva more quickly and increase the salivary flow rate. The salivary flow rate correlates significantly with the buffer system, directly affecting salivary pH. This mechanism can happen because the bicarbonate system strongly influences the pH of saliva. The bicarbonate system is very effective in neutralizing acid and is directly proportional to the salivary secretion rate.[14,16,30,31]

The comparison between the two groups showed no significant difference between the mean difference in pH values and salivary flow rates before and after chewing fruit. These results are supported by research conducted by Kurniawan (2018) and Arini DS et al. (2016), who reported that consuming grapes and strawberries can increase the pH value and salivary flow rate. The denser strawberries' texture and sour taste result in more significant and longer chewing power. Each of the two fruits has advantages that can help increase the pH value and salivary flow rate. The results obtained can be influenced by each research subject's amount of chewing pressure.[14,15]

The water and fibre content in grapes and strawberries can increase salivary secretion. *Saliva* is an exocrine fluid secreted by three major salivary glands and many minor salivary glands and has an essential role in maintaining oral and dental health. Normal salivary secretion is about 800 to 1,500 ml per day, with an average daily value of 1000 ml. The role of saliva in the oral cavity is crucial to maintaining oral health. The function of saliva as self-cleaning is carried out through the flow of saliva, which helps remove pathogenic bacteria and food particles that bacteria can metabolize to become pathogens. Antimicrobial enzymes in saliva work non-specifically, such as lysozyme, to lyse

bacterial cell walls. Lactoferrin works to kill bacteria. Myeloperoxidase, which forms hypothiocyanite, oxidizes bacterial enzymes and kills bacteria to protect the oral cavity. Saliva also contains protein antibodies that can destroy bacteria in the oral cavity, including plaque-forming bacteria. An increase in salivary pH and the increase in the concentration of bicarbonate ions play a role in the buffering function of saliva. It prevents the demineralization of hard tooth tissue by acids. They can increase the remineralization process of teeth.[13,18,30,32-34]

This study showed that the pH value of saliva before and after chewing fruit remained in the normal range (pH 6.8 - 7.4) in both the grape and strawberry groups. A pH value in this range is needed to maintain a balance of conditions in the oral cavity. Saliva can regulate the buffer balance to minimize acid-base by holding down the pH value or oral acidity. This condition is also related to the viscosity or volume of saliva. The pH value of saliva is one of the defence barriers in the oral cavity. A person can become susceptible to oral and dental diseases by changes in the pH value of saliva. Salivary pH below normal causes the oral cavity to become acidic. It facilitates the growth of bacteria such as *Streptococcus mutans*. And they were demineralizing the tooth surface and caries formation. A pH value above average can increase calculus formation; this occurs because of the ionized phosphate ion [PO_4^{3-}] in saliva and plaque resulting from the breakdown of organic phosphate by the salivary phosphatase enzyme plaque calcification into calculus. [23,33,35,36]

Salivary secretion is regulated by a reflex involving the autonomic nervous system called the salivary reflex, which consists of a conditional and unconditioned salivary reflex. Conditional salivary reflex occurs without oral stimulation; this reflex comes from the process of seeing, smelling, hearing, or thinking about the preferred food that has been learned based on previous experience. Stimulation outside the oral cavity works through the cerebral cortex to stimulate the salivary centre in the medulla oblongata. While the salivary reflex is not conditional, stimulation comes from the mouth area through chemical or mechanical stimuli from food or other objects, the effects of taste sensations, and movements caused by jaw and tongue movements. Stimulated salivary secretion causes an increase in salivary flow rate due to an increase in salivary flow velocity. The increase in salivary flow rate is directly proportional to the increase in buffer capacity, with the increase in bicarbonate ions to maintain the pH value of saliva to remain stable. [30,37-39]

Salivary secretion in this study results from an unconditioned salivary reflex, namely from chemical stimulation originating from the effects of taste sensations and direct mechanical stimulation in the oral cavity. Mechanical stimulation occurs touch on the tongue and oral mucosa. The masticatory muscles' proprioceptive stimulation stimulates the salivary centre in the brain to secrete saliva. Receptors in the oral cavity, both chemoreceptors and pressure receptors, will respond to stimulation in the oral cavity. These receptors then generate impulses of afferent nerve fibres carrying information to the salivary centre in the brainstem's medulla. The salivary centre then sends impulses through the extrinsic autonomic nerves to the salivary glands to increase salivary secretion and then increase the salivary pH.[30,31,39]

In this study, the increase in pH value and salivary flow rate after chewing grapes and strawberries was directly proportional. Consuming foods that contain much water, such as grapes and strawberries, through the mastication process can help increase the self-cleaning effect in the oral cavity by stimulating salivary secretion, which affects the flow rate and pH value of saliva. Chewing movement is a mechanical crushing process of food. It is carried out in the oral cavity using the teeth and the help of masticatory muscles. The muscles include the masseter, temporalis, lateral pterygoid, and medial pterygoid muscles, which help the teeth to contact each other. The strength of the bite of each person is different, which is influenced by chewing habits, the condition of the teeth, and supporting tissues. During the chewing process, the water and fibre content in grapes and strawberries causes a shift in the fibres so that they can release food debris that is attached to the tooth surface. In addition to water and fibre, the vitamin C content in fruit can also stimulate salivary secretion, which will increase the salivary flow rate and salivary pH to inhibit the process of bacterial colonization and dissolve the plaque that has formed.[10,40,41]

Although this study showed that the pH value and salivary flow rate increased after chewing grapes or strawberries, mechanical plaque control efforts, namely by brushing teeth, should still be carried out as the primary plaque control. Chewing grapes and strawberries can only prevent the accumulation of plaque that can cause caries and periodontal diseases.

CONCLUSION

This study showed that the pH value and salivary flow rate after chewing grapes and strawberries increased

significantly compared to before chewing these fruits. This condition is a good indicator of oral hygiene. The average increase after chewing the two fruits was not significantly different. This result shows that consuming both fruits is equally suitable for maintaining oral and dental hygiene. Nevertheless, the main mechanical plaque control effort, namely brushing teeth, must still be carried out regularly. Chewing grapes and strawberries can be done to prevent plaque accumulation, which is the leading cause of caries and periodontal disease.

CONFLICT OF INTEREST

We declare no potential conflict of interest in the scientific articles we write.

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