International Research Journal of Pharmacy and Medical Sciences
ISSN (Online): 2581-3277

Differences in Flow Rate and Salivary Acidity Level in Soft Drink Drinkers and Milk Drinkers (Systematic Literature Review)

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***Abstract*— *Saliva is a complex fluid in the oral cavity, consisting of a mixture of major and minor salivary gland secretions with a salivary pH ranging from 6.5-7.4. Several factors cause changes in salivary pH, including salivary flow rate, oral flora normal, salivary buffer capacity, and food and beverages consumed; one of which is milk and soft drinks. Milk provides a wide variety of nutrients, including proteins, minerals, and vitamins. Alcohol is not present in soft drinks, which come in liquid or powder form and contain food ingredients and other additives, both natural and artificial, packed and ready for consumption. In this study, saliva flow rates and pH levels were compared between milk drinkers and soft drink consumers to see how they differed. The research method used is Systematic Literature Review (SLR) with 3 journal databases namely PubMed, Science Direct and Google Schoolar. Based on the literature search, 322 literatures were obtained, which were checked for duplication of articles with Mendeley software. Screening was carried out on the literature based on the title and abstract so that 14 literatures were obtained that met the eligibility and were analyzed further. The results show that there are two literatures stating that there is an increase in salivary flow rate in soft drink and milk drinkers. Seven literatures state that there is an increase in the degree of salivary acidity in soft drink drinkers. There was a decrease in the level of salivary acidity in milk drinkers, according to five pieces of literature. The conclusion shows that the condition of salivary flow rate in soft drink and milk drinkers increases. Soft drink drinkers have more salivary acidity than milk drinkers do.*

***Keywords*—** *Salivary Flow Rate, Salivary Acidity Level, Salivary pH, Milk, Soft Drinks*.

I. INTRODUCTION

Drinking water is a daily human need that serves as a thirst quencher. Food technology has created a variety of food and beverage preservatives, additives and flavor substances. These soft drinks are known throughout the world including Indonesia. Negative impacts also arise, including degenerative diseases. Since the invention of soft drinks in the United States, there has been a sharp increase in consumption from year to year, followed by other countries. In 1986, consumption was about 28 gallons per capita/year, then increased to 41 gallons in 1997. These drinks are even consumed by 74% of the population of children/adolescent boys and 64% of children/adolescent girls.[1]

Soft drinks are drinks that do not contain alcohol, these drinks are processed in powder or liquid form containing food ingredients and other additives both natural and synthetic which are packaged in packages ready for consumption. Soft drinks often add preservatives and artificial sweeteners whose levels need to be considered, because if excessive consumption can affect health. Soft drinks consist of two types, namely: soft drinks with carbonate and soft drinks without carbonate.[2] The composition of soft drinks is generally very simple, consisting of 90% water and the rest is a combination of artificial sweeteners, carbonated water (soda water), flavor enhancers, dyes, phosphoric acid, caffeine, and some minerals, especially aluminum.[1,3]

A drink that is often consumed by the public is milk. Milk contains many nutrients that are good for children, one of which is a source of calcium. Based on the statistics of Peternakan dan Kesehatan Hewan (PKH), fresh milk production in Indonesia increased every year, from 827,249 tons in 2009 to 981,586 tons in 2013. Milk consumption in Indonesia itself is still quite low for people with middle to lower economy, because they think that milk is an expensive food.[4]

Milk is a white liquid, obtained from the juice of lactating animals, which can be eaten or used as a healthy food ingredient, and in which no other ingredients are reduced or added. Milk contains almost all food substances such as carbohydrates, proteins, minerals, and vitamins and is a vegetable protein that has a complete essential amino acid content (Hadiwiyoto 1994).[5] The average milk composition is water (87.90%), dry matter (12.10%) consisting of fat (3.45%) and lean dry matter (8.65%). Non-fat dry matter consists of protein (3.20%), lactose (4.60%), vitamins, enzymes, gas (0.85%). Protein is divided into casein (2.70%) and albumin (0.50%). The energy content is 65kcal, the pH of milk is 6.7.[6]

In the oral cavity, pH is maintained near neutral (6.7-7.3) by saliva. Saliva contributes to pH maintenance by two mechanisms. First, salivary flow dissolves carbohydrates that can be metabolized by bacteria and removes acids produced by bacteria. Secondly, acids in beverages and food, as well as acids from bacterial metabolism are neutralized by salivary buffering activity.[7]

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Saliva plays a major role in maintaining oral health, changes in homeostasis maintained by saliva bring about poor oral health. It has a specific role in the oral cavity. The buffering capacity of saliva helps in neutralizing the acids produced by plaque from food and drinks. Since saliva contains calcium and phosphate ions in balance with enamel, dissolution of enamel does not occur. When the pH of saliva drops below the critical pH, enamel larut untuk memulihkan keseimbangan ion kalsium dan fosfat kepada normal.[7]

In addition, when the salivary pH drops below the critical pH, the salivary flow rate will increase (Millward, Shaw, Harrington, & Smith, 1997) and will be diluted by saliva (Dawes & Macpherson, 1992).[8]

Based on the study, within 6.5 minutes after drinking milk, the salivary pH will return to the normal pH as before the subject consumed milk.[9] The salivary flow rate increases with increasing protein concentration in milk.[10] Research by Rahmawati (2015) concluded that consuming too many soft drinks a day will result in a decrease in salivary pH below normal, carbonated products increase salivary secretion.[11,12] When the amount of salivary flow decreases, it can increase the frequency of dental caries, and inflammation of the parotid gland. At low salivary pH, microorganisms can develop well. Conversely, a high pH can prevent dental caries.[13]

Oral health has an important role in speech function, mastication, self-confidence. Therefore, oral hygiene must be maintained as well as possible. The effects of unmaintained oral hygiene cause dental caries, periodontal disease and so on. The results of RISKESDAS 2013 stated that the national prevalence of oral health problems was 25.9%, where the prevalence of North Sulawesi was 31.6%. The most common oral disease suffered by the community is dental caries followed by periodontal disease in second place. Caries is damage to hard tooth tissue caused by acids contained in carbohydrates through the intermediary of microorganisms in saliva.[14]

Indonesia's DMF-T index in 2013 was 4.6, which means that the Indonesian population had 460 teeth per 100 people, while West Sumatra's DMF-T index was 4.7. The DMF-T index increases with age, which is 1.4 in the age group of 12 years, then 1.5 at the age of 15 years, 1.6 at the age of 18 years, and so on. 1 Indonesia is one of the countries in the highest DMF-T risk category for the Southeast Asian region in the distribution of dental caries according to WHO.[13]

II. METHOD

This study uses a systematic literature review using the PRISMA method (Preferred Reporting Items for Systematic Reviews and Meta-analyses) through four stages, namely identification, screening, eligibility and included. Literature searches were conducted by accessing electronic databases online from Pubmed, Science Direct and Google Scholar. At the beginning of the search with the database using inclusion criteria, namely journals and articles that examine the association of the impact between flow rate and salivary acidity level in soft drink and milk drinkers. Then using the exclusion criteria by looking at the publication time with a range of 2012-2022 and assessing by removing journals that have the same title and author, incomplete text and verifying research results such as sample adequacy, anticipation of bias, comparison groups, and the suitability of statistical tests from the literature list. In the final stage, the quality of the journals was reviewed according to the Newcastle-Ottawa Quality Assessment Scale Cross Sectional Study criteria.

III. RESULTS

The results of the search obtained a total of 322 literature from each of the 3 databases, namely from Pubmed 23 literature, Science Direct 16 literature, and Google Scholar 283 literature. Duplication checking using Mendeley software and found as much as 4 literature that was excluded because it was duplicate literature so that 318 literature was obtained which would be screened.

There were 46 literatures that were not full text and 15 literatures that were not in Indonesian or English. Further screening was conducted because the titles and abstracts did not have a relevant relationship with the inclusion criteria. The search ended with 14 literatures PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Fig.1). Table I illustrates the results of the literature findings that have been carried out.

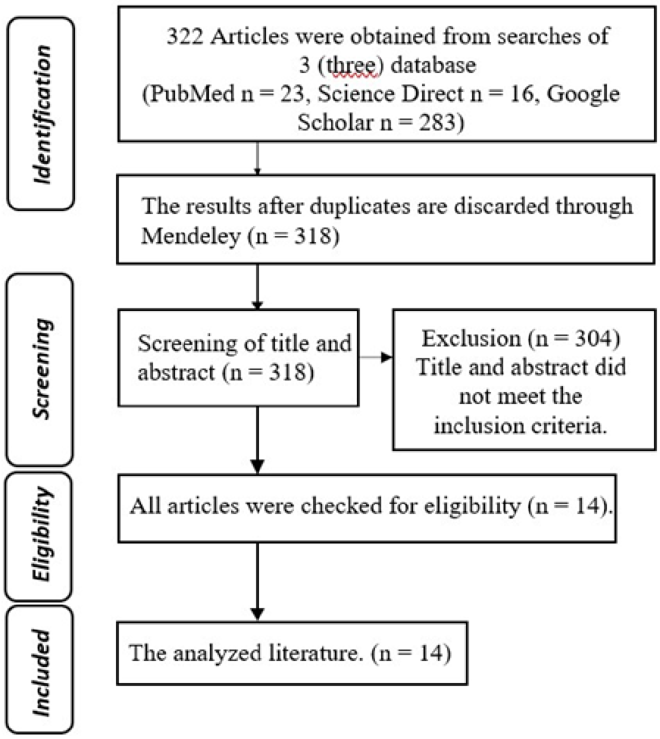

Fig. 1. Results of literature search with PRISMA stages.

IV. DISCUSSION

A. *Salivary Flow Rate and Level of Acidity in Carbonated and Uncarbonated Soft Drink Drinkers.*

The discussion of salivary flow rates in carbonated and non-carbonated soft drink drinkers was obtained from 2 (two) literatures. In non-carbonated drinks, Hildebrandt found the salivary flow rate of unstimulated and stimulated soft drink

Adib Hanifi bin Abd Aziz, Minasari Nasution, Ameta Primasari, Ika Astrina, “Differences in Flow Rate and Salivary Acidity Level in Soft Drink Drinkers and Milk Drinkers (Systematic Literature Review),” *International Research Journal of Pharmacy and Medical Sciences (IRJPMS)*, Volume 6, Issue 4, pp. 36-41, 2023.

drinkers slightly increased one hour after consumption of non-carbonated soft drinks. This literature suggests that both caffeinated and decaffeinated soft drinks have an association with increased salivary flow rate.[15]

Hans stated an increase in salivary flow rate from 1±0.13 mL/min to 1.78±0.16 mL/min after soft drink consumption. The findings of this study are consistent with other studies. According to the literature, liquids have a considerable cariogenic and erosive potential despite clearing the mouth cavity quickly. They cause a large decrease in salivary pH after consumption. Therefore, it is always recommended to minimize the consumption of soft drinks, especially among children and young adults, to maintain good oral health.[16]

A discussion of the degree of salivary acidity in carbonated and non-carbonated soft drink drinkers was obtained in 7 (seven) literatures. The research obtained all discussed the increase in the level of salivary acidity of carbonated and non-carbonated soft drink drink drinkers. Susanti's research stated that there was a decrease in salivary pH after consuming carbonated soft drinks, namely from 6.97 to 6.49 in the sample group with the habit of drinking carbonated soft drinks. In the sample group without the habit of drinking carbonated soft drinks, there was a decrease in pH after consuming carbonated soft drinks, namely from 7.01 to 5.71. This study supports previous research by Valentine in 2001 which states that salivary pH will decrease after being stimulated by carbonated soft drinks. Carbonated soft drinks have an acidic pH, so they can change the pH of saliva.[17]

Santoso's research stated that the pH of saliva after consuming fizzy tea decreased more than the decrease after consuming unfizzy tea. Non-fizzy tea decreased because it contains sugar. This literature states that the consumption of soft drinks affects the pH of saliva which can trigger the incidence of dental caries.[18]

Putu's research states that the average pH of saliva after consuming carbonated soft drinks has a lower average (6.558) than before consuming carbonated soft drinks (6.970), thus it can be seen that there is a decrease in pH after consuming carbonated soft drinks. The decrease in salivary pH after consuming soft drinks is also due to carbonated soft drinks having a very low pH or below the critical pH so that after consumption it causes an increase in acidity in the oral cavity. This literature states that there is a significant difference between the pH of saliva before and after consuming carbonated soft drinks is due to the capacity of the salivary buffer fluid not being able to withstand the decrease in pH, so it can be concluded that carbonated soft drinks can increase the acidity of the oral cavity.[19]

Hans' research stated that in his study added sugar to the carbonated beverage used, namely Pepsi, amounting to 10.6 grams/100 grams or 11 teaspoons of sugar in 300 mL, causing an instant decrease in salivary pH from 7.18 ± 0.22 to 5.65 ± 0.28. This could be as a result of the increased intrinsic acid content (kept in the range of 2-3) and sugar content (14.9 grammes in 100 mL) in carbonated beverages, which are to blame for their high cariogenic potential and erosivity.[16]

As anticipated, salivary pH acidification was seen in the first few minutes after exposure to the sucrose drink in Barajas' trial. This effect was similar to that reported by Sánchez et al. however, in his study a lower acidification was identified. This may be because Sánchez et al. evaluated the pH level from the first minute after ingestion, whereas in this study the measurement started at the 5th minute. This literature states that the consumption of carbonated beverages favors the proliferation of bacteria, which increases their cariogenic potential.[20]

Nora's research states that the more the frequency of drinking soft-drinks, the lower the pH of saliva in accordance with Aritonang's research in 2004 on the relationship between the frequency of drinking soft drinks to salivary pH. In his research, he concluded that consuming too many soft drinks a day will result in a decrease in salivary pH below normal. The frequency of consumption of risky soft drinks will cause changes in salivary pH to be in acidic conditions, causing demineralization of teeth. The more often a person consumes soft drinks in one day, it will increase the acidic pH of saliva.[21]

Ashwatha's research states that in the group consuming carbonated soft drinks, a drastic decrease in pH was observed from 6.88 to 6.66 after 5 minutes. At the 10th minute, there was a significant decrease observed in the pH value from 6.66 to 6.36 and at the 15th minute, there was a significant decrease in the pH value from 6.36 to 6.22. In the group consuming carbonate-free soft drinks, a decrease in pH was observed from 7.06 to 6.72 after 5 minutes. At the 10th minute, there was a slight decrease in pH observed from 6.72 to 6.54. The literature suggests that salivary pH becomes more acidic after consuming carbonated soft drinks and non-carbonated soft drinks.[22]

B. Salivary Flow Rate and Level of Acidity in Animal Milk and Powder Drinkers

The discussion of salivary flow rate in animal milk and milk powder was obtained from 2 (two) literatures. Mayasari's research stated that there was the highest difference in the average salivary flow before and after three days of consuming dairy products, which was 0.20 ± 0.31 ml/min. Milk contains high antioxidants that affect the breakdown of carbohydrates into lactic acid and aspartic acid. The acid produced is perceived as a taste stimulus that acts as a chemical stimulus to activate the central nervous system, upon receiving the stimulus, the brain is designed to secrete saliva by releasing a nerve transmitter, norepinephrine or noradrenaline which then binds to adrenergic type salivary gland receptors. Through these receptors, the salivary glands are stimulated to secrete a larger and thinner amount of saliva which signifies an increase in the salivary flow rate. Hans' study found an increase in salivary flow rate 0 minutes after consuming sweetened milk from 1.23±0.237 mL/min to 2.22±1.07 mL/min and then a decrease after 5 minutes and 10 minutes.[16,23]

Discussions about the degree of salivary acidity in animal milk drinkers and milk powder obtained 6 (six) literature. The research obtained 5 (five) literature discusses the decrease in the level of salivary acidity of animal milk drinkers and milk powder and 1 (one) discusses the increase in the level of salivary acidity in animal milk drinkers and milk powder.

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Sungkar's research found that there was an increase in salivary buffer capacity after milk consumption. According to the literature, cheese eating increases salivary buffer capacity more than milk consumption does.[24]

Wowor's study found that after consuming milk powder there was a greater decrease in salivary pH than consuming whole cow's milk. This is due to the carbohydrate content of milk powder in the form of lactose and also the addition of sucrose so that the pH of saliva after consuming milk powder has decreased more. This literature states that there is a significant difference between salivary pH after consuming whole cow's milk and cow's milk powder. There is a greater decrease in salivary pH after consuming cow's milk powder than after consuming milk.[14]

Mayasari's research states that animal milk is statistically more effective in increasing salivary pH after seven days of consumption. High antioxidants in milk are anticariogenic which are antibacterial and will reduce the breakdown of carbohydrates into lactic acid and aspartic acid by bacteria so that salivary pH increases. Protein in milk can increase salivary pH because it produces ammonia-based substances that increase salivary pH.[23]

Farooq's research found that the pure milk consumption group showed a significant decrease in pH at the 10th minute. However, the pH returned to normal at 15 - 30 minutes in the milk consumption group added with sugar. The acidity level of whole milk was higher than milk added with sugar at 5 minutes after consumption. A decrease in pH in the whole milk group from 7.20 to 7.01 at 5 minutes was observed, and then increased rapidly at 15 minutes and touched the baseline at 120 minutes.[25]

Cut's research found that the pH value of subjects who consumed formula milk decreased by an average of 0.1889, causing the subject's oral condition to be more acidic and the pH value of subjects who consumed UHT milk increased by an average of 0.1444, causing the subject's oral condition to be more alkaline. The protein content contained as much as 7g in UHT milk allows the release of more ammoniacal alkaline substances, so that the pH value of the subject's saliva increases.[9]

Alpna's research found that milk consumption caused an increase in salivary pH, the maximum decrease in milk saliva pH was seen at the 5th minute. After 30 minutes, the salivary pH of subjects in the group consuming milk was similar to the initial pH. The group that consumed milk also showed an increase in the average salivary pH level. The decrease in salivary pH within 5 minutes of consuming milk is similar to a 1985 study by Rugg-Gunn et al, in which sucrose solution caused a substantial decrease in plaque pH, while milk only slightly suppressed plaque pH. This literature suggests that milk and milk-derived products can be used as substitutes for high-carbohydrate desserts and snacks, which may reduce the incidence and prevalence of dental caries.[26]

C. Differences in salivary flow rate and salivary acidity between soft drink and milk drinkers

The difference in salivary flow rate in soft drink and milk drinkers was obtained in 1 (one) literature, namely in Hans' research, which stated that there was an increase in salivary flow rate from 1 ± 0.13 mL/min to 1.78 ± 0.16 mL/min after consumption of soft drinks and an increase in salivary flow rate after consuming sweet milk from 1.23 ± 0.237 to 2.22 ± 1.07 mL/min. Both soft drink and milk drinkers experienced an increase in salivary flow rate.[16]

Apart from the literature carried out in one study, there is literature that can be compared with the results on the condition of salivary flow rate after consuming soft drinks and milk. As discussed earlier, Mayasari's study found an increase in salivary flow rate after consuming milk. Hildebrandt's study found the salivary flow rate of unstimulated and stimulated soft drink drinkers increased slightly one hour after consuming soft drinks.[15,23]

The difference in the degree of salivary acidity in soft drink and milk drinkers was not found in the literature, but based on other literature there are 7 (seven) which state that there is an increase in the level of salivary acidity after consuming carbonated and non-carbonated soft drinks and 5 (five) literature which states that there is a decrease in salivary acidity after consuming milk. It was observed that the salivary acidity level in soft drink drinkers was higher than milk drinkers.

V. CONCLUSION

From all the literature that has been reviewed, it can be concluded that there is an increase in salivary flow rate and level of salivary acidity in carbonated and uncarbonated soft drink drinkers after consuming carbonated and uncarbonated soft drinks. Then, there is a decrease in salivary flow rate in animal milk and powdered milk drinkers after consuming animal milk and powdered milk. However, there is a difference in salivary acidity level in milk powder drinkers, which is slightly increased compared to animal milk drinkers because powdered milk contains added sugar. Finally, there was an increase in salivary flow rate in soft drink and milk drinkers after consuming soft drinks and milk. The salivary acidity level in soft drink drinkers was higher than milk drinkers.

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TABLE I. Findings from Literature

No	Researcher (Year)	Title	Place of study, Method, Sample size	General Findings
1	Susanti et al, 2016.	Pengaruh Minuman Ringan Berkarbonat Yang Mengandung Kafein Terhadap pH Saliva	• Indonesia • Cross Sectional 21	Increased in salivary acidity level in carbonated soft drink drinkers from 7.01 to 5.71
2	Sungkar et al, 2020.	The Effect of Cheese and Milk on Buffering Capacity of Saliva in Children 10-12 Years	• Indonesia • Cross Sectional 22	There was an increase in buffer capacity after consuming milk.
3	Wowor et al, 2018.	Perbedaan pH Saliva Setelah Mengonsumsi Susu Sapi Murni dan Susu Sapi Bubuk	• Indonesia • Cross Sectional 38	There was a greater decrease in salivary pH in milk powder drinkers than in cow's milk drinkers.
4	Santoso et al, 2022.	Effects of Carbonated Soft Drink on Saliva pH in the Occurrence of Dental Caries	• Indonesia • Cross Sectional 18	Salivary pH after consuming fizzy tea decreased more than non-fizzy tea.
5	Putu et al, 2018.	Minuman Ringan Berkarbonasi Dapat Meningkatkan Keasaman Rongga Mulut	• Indonesia • Cross Sectional 50	There was an increase in salivary acidity level after consuming carbonated soft drinks from 6.970 to 6.558.
6	Mayasari et al, 2019.	Dairy Product Consumption Effects on Increasing Salivary pH, Flow, and Calcium Ion	• Indonesia • Cross Sectional 25	• There was an increase in salivary flow rate after consuming milk with an average of 0.20 ± 0.31 mL/min. There is an increase in the level of salivary acidity level after consuming milk from 7.25 ± 0.12 to 6.91 ± 0.13
7	Hildebrandt et al, 2013.	Effect of Caffeinated Soft Drinks on Salivary Flow	• Indonesia • Cross Sectional 38	There was an increase in salivary flow rate after consuming carbonated soft drinks from 0.21mL/min to 0.23±0.02 mL/min
8	Hans et al, 2016.	Effect of Various Sugary Beverages on Salivary pH, Flow Rate, and Oral Clearance Rate amongst Adults	• Indonesia • Cross Sectional 120	• An increase in salivary flow rate after consuming carbonated soft drinks from 1±0.13mL/min to 1.78±0.16 mL/min • Increased salivary acidity after consuming carbonated soft drinks from 7.18±0.22 to 5.65±0.28 Found higher salivary flow rate after consuming sweetened milk from 1.23±0.237 mL/min to 2.22±1.07 mL/min
9	Farooq et al, 2016.	Comparison Of Changes In Salivary pH Levels After Consumption Of Plain Milk And Milk Mixed With Sugar	• India • Cross Sectional 60	Increased in salivary acidity level after consuming milk from 7.26 to 7.01
10	Cut et al, 2017.	Perbedaan pH Saliva Sebelum dan Sesudah Mengonsumsi Susu Formula Dengan Susu UHT (Studi pada Anak di Panti Asuhan Nirmala Banda Aceh)	• Indonesia • Cross Sectional 27	Milk powder drinkers experienced a decrease in pH with an average of 0.1889
11	Barajas et al, 2022.	Effects of Carbonated Beverage Consumption on Oral pH and Bacterial Proliferation in Adolescents: A Randomized Crossover Clinical Trial	• Mexico • Cross Sectional 18	Increased in salivary acidity level after consuming carbonated soft drinks from 7.05 to 6.80
12	Ashwatha et al, 2019.	Comparing the effect of Carbonated and energy drinks on salivary pH- in vivo randomized controlled trial	• India • Cross Sectional 20	Increased salivary acidity level after consuming carbonated soft drinks from 6.88 to 6.22
13	Alpna et al, 2018.	Milk and Its Products: Effect on Salivary pH	• India • Cross Sectional 30	Milk drinkers experienced an increase in salivary pH after consuming milk.
14	Nora et al, 2019.	Hubungan Konsumsi Minuman Ringan Dengan pH Saliva Pada Mahasiswa Program Studi Kedokteran Fakultas Kedokteran Universitas Malikussaleh Tahun 2019	• Indonesia • Cross Sectional 57	High frequency of softdrink consumption resulted in low salivary pH.