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EFFECT OF BAKING SODA SOLUTION ON SALIVA PROPERTIES IN A GROUP OF CHILDREN: A RANDOMIZED CONTROL TRIAL

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ABSTRACT

Aim: To measure the effect of baking soda oral rinse on saliva properties of active caries and caries free children

Methods: This is a randomized controlled clinical study with a sample of 96 children with mean age 10.4 years old selected and divided into two main groups; group (1) include 48 children with active caries and group (2) include 48 caries free children. Saliva samples were taken at baseline and after drinking sugary juice then all children were further divided randomly from each group into two subgroups. Group A: (test) include 24 children rinsed using Baking Soda 2% and Group B: (control) include 24 children rinsed using distilled water. Flow rate, pH and buffer capacity of saliva samples were measured after rinsing with distilled water or BS. The group comparison was done using Student's t-test. A value of $P<0.05$ was considered significant.

Results: After rinsing with BS the pH, flow rate and buffer capacity of saliva were increased than rinsing with distilled water in both caries free and caries active children.

Conclusion: BS 2% solution enhances the pH, flow rate and buffer capacity of saliva compared to distilled water if rinsed directly after a significant drop in saliva properties followed by sugar consumption.

KEY WORDS: Baking soda, saliva, children

INTRODUCTION

Saliva is the principal defense mechanism agent in maintaining the health of the oral cavity. It is considered to be a key determinant of the surroundings of all the oral tissue surfaces. Salivary proteins along with some minerals having binding properties seem to develop acquired pellicle formation.[1]

The salivary pellicle plays the fundamental role in teeth crystal growth process which helps in protection of the teeth surfaces in both physical and chemical means as well as in balancing bacterial adhesion and or colonization to tooth surfaces which may lead to decrease caries development and gingival diseases.[2, 3]

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Adequate salivary physical properties are critical to the maintenance of the health of the oral tissues; flow rate function in flushing, dilute substance and neutralizing effect is vital and referred to salivary clearance, so higher flow rate leads to faster clearance. [4]

Moreover, the salivary flow rate was found lower in children in 6 to 12 year old than adults 19 to 44 year old which in turn affects caries susceptibility in children.[5]

The pH of the saliva solution and dental plaque is a critical factor that balances acid demineralization and the remineralization of the teeth of the initial caries lesion. Plaque pH falls each time acid accumulates in the plaque due to aciduric bacteria by-products following the consumption of cariogenic material such as sugars. On the other hand, plaque pH increases when the acids are removed or neutralized by saliva, which contains a buffer system. [6]

It is known that the buffer action of saliva is achieved by bicarbonate, phosphate, urea, and amphoteric proteins and enzymes. Bicarbonate is the mainly significant buffer system. It diffuses into plaque and neutralizing acids produced from dietary sugars by oral bacteria; it can repeal the decreased pH in saliva and allow for remineralization of enamel. [7]

Sodium bicarbonate also Known as Baking Soda is the chemical compound secreted naturally in saliva in the formula $NaHCO_3$.[8]

Sodium bicarbonate is a potent cleaning agent that decreases viscosity of mucus helping to eliminate it and detach soft debris. [9] Although sodium bicarbonate might not possess direct antimicrobial effects, except for inhibition of overgrowth of aciduric bacteria, some oral hygiene products contain sodium bicarbonate proved their effectiveness in oral health care as it raises the saliva pH and compensates the acidic change of the saliva.[10,11]

Although some mouthwashes available are strong anti-bacterial agents they are not completely safe for children and a lot of many restrictions were accompanied by their use as they contain ethanol base and /or fluoride. [12, 13]

Baking Soda is diluted in water for safe use; it is stable on open air and room temperature, so it can be stored directly in a closed container, without additional special treatment. In addition, it was found to be less irritating to the oral mucosa of children compared to chlorhexidine. [14]

From the previous knowledge, this study was conducted to evaluate the effect of sodium bicarbonate on saliva properties in children after acidic challenge.

MATERIALS METHODS

A- Participants' selection

Our study was a double-blinded randomized controlled clinical study (the participant did not know if the bottle was distilled water or SB, also the examiner did not know which bottle is distilled water and which is SB and all bottles were marked with numbers 1 or 2 with reference points)

A pilot study was conducted on 24 children (12 children with high caries index and 12 caries-free children) the pH, flow rate and buffer capacity of saliva were measured before and after rinsing with SB solution the mean difference of all saliva properties were higher after rinsing with SB and this difference was statistically significant after treatment of the data by Student's t-test. From previous results, the sample size was estimated to be 96 children, 48 children in each group with a minimum of 24 samples in each subgroup. These participants were, however, not included in the main study. The sample size was calculated using nMaster 2.0 (CMC, Vellore, India).

A total of 96 children (50 female and 46 male) aged 9-11 years with a mean age 10.4 years old participated in this study. They have had been

selected from outpatient clinic, Baterrje Medical College, KSA Ethical approval for this study was obtained from the Ethical committee ((REC 20/7-00/6); the written consent was signed and obtained from caregivers.

Inclusion criteria: All children selected were cooperative and free from any systemic disease

Exclusion criteria any uncooperative, anxious child or child have any medication during all periods of the study was excluded from the study.

Subjects were divided into two main groups:

Group 1: 48 children with high caries index (deft + DMF-t ≥ 6) [15] Group 2: 48 children with no caries

Caries examination: Caries status was assessed according to the WHO criteria [16] and the indices used were deft for primary teeth and DMFT for permanent teeth.

Children in group 1 and group 2 were further divided randomly into two groups:

Group (A) test group; 24 children were received sodium bicarbonate oral rinse

Group (B) control group; 24 were received distilled water oral rinse (placebo)

The randomization was done by dental recipients by choosing a child to either group by the toss of a coin, after that the next child went to the other group.

B- Materials preparation:

A concentration of 2% Sodium bicarbonate was freshly prepared by dissolving 5gm of sodium bicarbonate powder in 250 ml of distilled water(17) Bottled 2% sucrose contains juice 250 ml volume.

Bottled distilled water 250 ml volume.

C-Conduction and measurements:

The pH, un-stimulated saliva flow rate and buffer capacity were measured at baseline T_0 in all children. Subsequently, children were instructed to drink the juice for 2 minutes and 5 minutes, then the pH, buffer capacity and flow rate of saliva were measured from the beginning of drinking. Children in both groups were divided into two subgroups (n=48) wherein child rinsed with 250 ml of Sodium Bicarbonate for 30 seconds in one subgroup (Test) and with same amount of distilled water solution for the same time in the other subgroup (Control) then after 5 minutes from the beginning of rinsing, the pH, buffer capacity and flow rate of saliva were measured.

The saliva samples were collected from all children at morning with no oral intake of food or drinks and with no oral hygiene measures being performed in the previous 2 hours. For the collection of the samples, the children were seated in upright position, with the head and trunk inclined forwards to collect the saliva. The collection was started with the instruction to void the mouth from saliva by swallowing; then the children spit the whole saliva directly into the test tube, this procedure was repeated every 10 seconds periodically till 5ml of saliva was collected, and the final rate was calculated milliliter each minute. The buffer capacity of saliva was measured by Ericsson's electrometric method [18]; 0.2ml of 0.01 N HCl was added to saliva samples and mixing the compound with stick. The electrode of pH meter was engrossed and the reading was recorded. The process of adding 0.2 ml of 0.01 N HCl was frequent, and pH was recorded until a pH value between 4.0 – 5.0 was reached, and the amount of acid added was calculated.

For statistical data analysis, the salivary flow rate, pH and buffer capacity data at base time, after sucrose consumption and after either distilled water or baking soda rinsing were compared by one-way analysis of Variance test.

Data thus obtained were tabulated accordingly and subjected to statistical analysis (SPSS Ver.17). The group comparison was done using Student's t-test. The Confidence Interval was set at 95% and a value of $P<0.05$ was considered significant.

RESULTS

1- Comparison between saliva pH, flow rate and buffer capacity at base time T_0 in caries free and high caries children

The results of this study showed that pH and buffer capacity of saliva in caries-free children was statistically significant higher than that showed in saliva of high caries children. However the flow rate of saliva in caries-free children was higher than in high caries children but the difference was statistically insignificant. (Table 1)

2- Comparison between saliva pH, flow rate and buffer capacity before and after consumption of sugary juice in caries free and high caries children

A- The results of this study showed that pH and Buffer capacity of saliva in high caries children decreased significantly after consumption of sugary juice however the salivary flow rate was increased but the difference was statistically insignificantly. (Table 2)

B- The results of this study showed that pH and Buffer capacity of saliva in caries-free children decreased significantly after consumption of sugary juice however the salivary flow rate was increased but the difference was statistically insignificantly. (Table 3)

3- Comparison between test and control in high caries main group

A- Salivary pH Analysis:

In our study the mean salivary pH of High Caries Control (HCC) was found to be 5.62 (SD ± 0.13) and of High Caries Test (HCT) was 6.99 (SD ± 0.71). When the mean salivary pH of these High Caries groups were compared there was a statistically high significant difference ($p<0.05$) (Table 4).

B- Salivary BC Analysis

When the mean BC of High Caries Control (HCC) was compared to High Caries Test (HCT) groups there was a significant difference ($p<0.05$) The mean salivary BC were higher in High Caries test group than High Caries Control group (Table 5)

C- Salivary FL Analysis

When salivary flow rate was compared between High Caries Control and High Caries Test group there was no significant results measured even though the mean Flow rate was higher in the High Caries Test group (0.740 ± 1.20) than High Caries Control (0.350 ± 0.940). (Table 6)

4- Comparison between test and control in caries free group

A- Salivary pH Analysis:

The mean salivary pH of Caries Free Control (CFC) was found to be 7.05 (SD ± 0.21) and Caries Free Test (CFC) group was 7.20. There was a statistical significant results between these groups when the mean salivary pH were compared ($p<0.05$) (Table 7).

B- Salivary BC Analysis:

In Caries Free Control group (CFC) the mean Salivary BC were lower (4.72 ± 0.39) compared to Caries Free Test group (CFT) (5.2 ± 0.49) and the difference were statistically significant when compared ($p<0.05$) (Table 8).

C- Salivary FL Analysis:

In Caries Free groups (CFC and CFT) there was no statistical significant difference observed between the mean salivary Flow rates (Table 9). There was also no significant difference between High Caries Control (HCC) and Caries Free Control Groups (Table 9). In both test groups the mean salivary flow rate was almost similar and there was no significant difference observed (Table 9).

5-Delta change in variables

The change in pH after rinsing with BS was found to be high in High caries children than in caries-free and this difference was statistically significant. However the **Δ** BC and **Δ** FL were also high but it was statistically insignificant.(Table 10)

TABLE (1) Showing pH, Flow Rate and Buffer Capacity of saliva in Caries Free Children and Children with High Caries at baseline

Group n=48	**HC**	**CF**	t value	df	standard error of difference	P value	95% Confidence Intervals
pH	**6.44**±0.22	**7.13**±0.11	19.435	94	0.036	<0.0001*	-0.7605 to -0.6195
FL	**0.33**±0.9	**0.41** ±0.45	0.5508	94	0.145	0.5831	-0.3684 to 0.2084
BC	**4.12**±0.23	**5.18 ±** 0.29	19.841	94	0.053	<0.0001*	-1.1661 to -0.953

TABLE (2) Showing pH, Flow rate and buffer capacity of saliva in high caries children before and after consumption of sugary Juice

Group n=48	**HC(b)**	**HC(s)**	t value	df	standard error of difference	P value	95% Confidence Intervals
pH	**6.44**±0.22	**5.56**±0.12	24.329	94	0.036	<0.0001	0.8082 to 0.9518
FL	**0.33**±0.9	**0.43±0.94**	0.5508	94	0.188	0.5957	-0.4730 to 0.2730
BC	**4.12**±0.23	**3.46±0.25**	13.4605	94	0.049	<0.0001	0.5626 to 0.7574

TABLE (3) Showing pH, flow rate and buffer capacity of saliva in caries free children before and after consumption of sugary Juice

Group n=48	**CF(b)**	**CF(s)**	t value	df	standard error of difference	P value	95% Confidence Intervals
PH	**7.13**±0.11	**6.35 ±0.19**	24.6145	94	0.032	<0.0001	0.7171 to 0.8429
FL	**0.41** ±0.45	**0.54 ±0.5**	1.4959	94	0.087	0.5831	-0.3025 to 0.0425
BC	**5.18**±0.29	**4.3**±0.36	13.1887	**94**	0.067	**<0.0001**	0.7475 to 1.0125

TABLE (4) Comparison of pH Between High Caries Control (HCC) and High Caries Test (HCT) groups

Group	**HCC** pH	**HCT** pH	t value	df	standard error of difference	p value	95% Confidence Intervals
Mean	5.6200	6.9900	9.2984	46	0.147	**0.0001**	-1.666575 to -1.073425
SD	0.1300	0.7100					
SEM	0.0265	0.1449					
N	24	24					

TABLE (5) Comparison of BC between High Caries Control (HCC) and High Caries Test (HCT) groups

Group	**HCC** BC3	**HCT** BC3	t value	df	standard error of difference	P value	95% Confidence Intervals
Mean	3.9800	4.6300	8.3167	46	0.078	0.0001	-0.8073 to -0.4927
SD	0.2500	0.2900					
SEM	0.0510	0.0592					
N	24	24					

TABLE (6) Comparison of Salivary Flow Rate between High Caries Control (HCC) and High Caries Test (HCT) groups

Group	**HCC**	**HCT**	t value	df	standard error of difference	P value	95% Confidence Intervals
Mean	0.3500	0.7400	1.2534	46	0.311	0.2164	-1.0163 to 0.2363
SD	0.9400	1.2000					
SEM	0.1919	0.2449					
N	24	24					

Table (7) Comparison of pH Between Caries Free Control (CFC) and Caries Free Test groups (CFT)

Group	CFC	CFT	t value	df	standard error of difference	p value	95% Confidence Intervals
Mean	7.05500	7.20000	2.1757	46	0.067	**0.0348**	-0.27915 to -0.01085
SD	0.21000	0.25000					
SEM	0.04287	0.05103					
N	24	24					

TABLE (8) Comparison of BC between Caries Free Control (CFC) and Caries Free Test groups (CFT)

Group	CFC BC3	CFT BC3	t value	df	standard error of difference	P value	95% Confidence Intervals
Mean	4.7200	5.2000	3.7549	46	0.128	0.0005	-0.2227 to 0.7373
SD	0.3900	0.4900					
SEM	0.0796	0.1000					
N	24	24					

TABLE (9) Comparison of FR between Caries Free Control (CFC) and Caries Free Test groups (CFT)

Group	CFC FR3	CFT FR3	t value	df	standard error of difference	P value	95% Confidence Intervals
Mean	0.5600	0.7000	0.5600	0.7000	0.5600	0.7000	0.5600
SD	0.5900	0.6800					
SEM	0.1204	0.1388					
N	24	24					

TABLE: (10) comparisons between the saliva properties difference in Caries Free test and High Caries test groups

Parameter	High Caries	Caries Free	P value
Δ pH	1.43	0.85	0.002*
Δ BC	1.1700	0.900	0.1513
Δ FL	0.3100	0.1600	0.9371

DISCUSSION

Oral hygiene measures is an integral part of preventive dentistry, one of the important measures that significantly help in the prevention of oral diseases is oral rinse in children. [19] Sodium bicarbonate has been used in dentifrices and proven to be effective in reducing dental plaque. [20]

Decreased salivary pH through consumption of acidic drinks was found to adversely affect oral health especially in demineralization of enamel, and giving an opportunity for growth of aciduric harmful bacteria leading to development and progression of dental caries. [21,22]

This study evaluated the compensating effect of Baking Soda on saliva pH, flow rate and buffer capacity after consumption of sucrose rinsing.

In this study, all children with medical conditions or appeared anxious or fearful were excluded as those factors may affect saliva properties. [23,24]

The buffer capacity of saliva could be measured by many methods; colorimetric and electrometric method. In this study we use the former as it depend on numbers rather colors change

Regarding saliva flow rate there are two methods of collection of saliva; resting and stimulated we collected resting saliva as the between and within subject variances were higher in comparison to stimulated method as reported by Navazesh et al.[25]

In this study, the pH and buffer capacity of saliva in caries-free children were higher than children with high caries. Almost similar results were also observed by **Picco et al** [26] they found that salivary pH, buffer capacity and flow rate of saliva was higher in caries-free children than in children with high caries These findings may be due to the ability of saliva to resist the decrease of pH may enhance teeth remineralization process and decrease incidence of dental caries.[27] However, regarding the salivary flow rate our results showed that there is no

statistical difference between high caries and caries-free children and these results were against **Picco et al**. as in their studies they collected stimulated saliva while our study utilizes unstimulated saliva and our results were in agreement with **Cunha-Cruz J et al** [28] they found that salivary flow rate was not statistically significant in caries free and children with high caries in contrast to **Leone CW** [29] he found strong correlation between salivary flow rate and caries incidence.

Our results suggested that sugary juice consumption by both caries free and high caries children decrease the buffer capacity and salivary pH when measured after 5 min.

as it is a well known that bacteria molder the sugar, they liberate lactic acid, butyric acid, and aspartic acid which falls the pH of saliva. [30]

Our results were in accordance with work of **Pachori et al** and **Azrak et al** [31, 32] they concluded that the drop in salivary pH and buffer capacity of saliva after sugary solution intake was statistically significant.

In both high caries and caries-free children, there was a statistically significant difference between test and control group and all saliva property values were increased after rinsing with Baking Soda indicating its strong and immediate effect on saliva pH, flow rate and buffer capacity. We can attribute this change to either the direct effect of BS on pH and buffer capacity or indirect effect on increasing saliva flow rate which in turn increased after rinsing with Baking Soda.

The Salivary pH raised after rinsing with Baking Soda than distilled water and this increase was statistically significant indicating the power of BS on saliva pH Since Baking Soda is a basic solution with pH between 8.0 and 8.6 (1 % solution) [33] it may raise pH of saliva after mouth rinsing. These results are in accordance with the findings of **Chandel et al**. [34]

In our study, the BC of saliva was enhanced by BS mouth rinse than distilled water. It is well known that Baking Soda has powerful BC (21) HCO_3^- makes H_2CO_3 by reacting with H^+ come from acid; H_2CO_3 resolves into CO_2 and H_2O. Hydrogen and bicarbonate ions form carbonic acid, which forms carbon dioxide and water. Carbon dioxide is exhaled and thus the acid is removed. [35]

This result is in accordance with **Zero**. [36] who concluded that Baking Soda could rapidly reverse the pH decrease after a sugar challenge.

Regarding flow rate, this study showed that an increased flow rate of saliva in both test groups (high caries and caries free) than in control groups. Thus the taste of Baking Soda may stimulate the saliva secretion in patients with hypo-salivation and decrease dry mouth sensation this observation was recorded by **Dewi et al, Ariyanti et al, and Manley**[37-39]

However, another study found that the salivary flow rate didn't enhance after bicarbonate chewing gum consumption compares to a standard gum. The difference may be related to the bicarbonate delivery system as we use solution while the former study used chewing gum. [40]

After rinsing with Baking Soda the change in saliva pH were higher in children with high caries than in caries-free children and this difference was statistically significant and this may indicate that the effect of Baking Soda on caries active children was more significant than caries-free children this may be explained on basis that Baking Soda affect more on lowered pH.

However, the change in both salivary buffer capacity and flow rate in caries-free children were higher than children with high caries but it was statistically insignificant.

Limitation of the study

It was a short term clinical study we didn't evaluate the effect of baking soda on saliva properties after a longer duration.

Other clinical studies are in need to find out the effect of Baking Soda mouth rinse on caries prevention

Single concentration SB was used in this study we did not use different concentrations of Baking soda solution to find out the optimum concentration improving saliva properties

CONCLUSION AND SUMMARY

After 30 seconds of rinsing with baking soda solution the pH, flow rate and buffer capacity of saliva were significantly improved in children with active dental caries and caries-free. The pH of saliva in the caries-active group was increased significantly more than in caries-free children. However, the flow rate and buffer capacity were not statistically improved in caries-active than caries-free children.

CONFLICT OF INTEREST

The authors have no conflict of interests for publication of this manuscript. All authors have made substantive contribution to this study and/or manuscript, and all have reviewed the final paper prior to its submission.

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Why this paper is important to pediatric dentists.

Dental caries in children has much negative influence on children and parents. Prevention of caries through improvement of saliva properties represents a challenge to clinicians.

Decreased saliva properties in children especially after sucrose consumption affect oral health and improvement of saliva properties in children is a fundamental process in caries prevention, this study provide mouth rinse able to enhance saliva pH, flow rate and buffer capacity after sucrose consumption include a relatively safe and less costly mouth (baking soda)

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