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A comparative analysis of bicarbonate-enriched vs. standard sugar-free chewing gums on salivary ph levels

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Abstract
Background: Salivary pH is a critical factor in maintaining oral homeostasis and preventing dental caries. This study was undertaken to address the role of salivary pH in preventing enamel demineralization, specifically comparing bicarbonate-containing gum to ordinary gum and a control group to identify interventions that effectively raise pH above the critical threshold of 5.5.
Materials and Methods: A randomized controlled study was conducted with 60 healthy participants (30 males, 30 females, mean age 22.9 years) divided into three groups: Group 1 (No gum/Control), Group 2 (Bicarbonate gum), and Group 3 (Ordinary gum). Salivary pH was measured using a high-accuracy digital pH meter at baseline (Before), immediately after intervention (T_i), at 5 minutes (T_5), and at 10 minutes (T_{10})
Results: At all post-intervention intervals (T_i, T_5, T_{10}), both gum groups showed a statistically significant increase in pH compared to baseline ($p < 0.001$). Group 2 (Bicarbonate gum) demonstrated the highest pH elevation (7.22 ± 0.17 at T_i) compared to Group 3 (7.13 ± 0.16) and Group 1 (6.49 ± 0.16). ANOVA confirmed significant intergroup differences ($p < 0.001$), and post hoc analysis revealed that bicarbonate gum was significantly more effective than ordinary gum ($p < 0.05$).
Conclusion: While the mechanical action of chewing ordinary gum elevates salivary pH, the addition of sodium bicarbonate provides a significantly more pronounced and sustained alkalizing effect, offering superior protection against acidic challenges.

Keywords: Salivary ph, bicarbonate-containing chewing gum, standard sugar-free gum, dental caries prevention, buffering capacity of saliva, enamel demineralization, randomized controlled trial, public health dentistry

Introduction

The oral environment is constantly under threat from acidic challenges arriving from dietary acids and the fermentation of carbohydrates by acidogenic bacteria. When the salivary pH drops below the critical threshold of 5.5, the protective mineral phase of dental enamel begins to dissolve, leading to dental caries [1]. Saliva serves as the primary natural defense mechanism, utilizing its flow rate and buffering capacity—predominantly the bicarbonate system—to neutralize these acids and facilitate remineralization [2].

Chewing gum has long been recognized as a physical stimulant that increases salivary flow, thereby enhancing the natural clearance of acids [3]. However, recent advancements in preventive dentistry have focused on "active" gums that incorporate buffering agents. Sodium bicarbonate, a natural component of saliva, is often added to these formulations to bolster the mouth's buffering capacity [4]. It can provide a vehicle for delivering medicaments, such as chlorhexidine, enzymes, fluoride and whitening agents [5]. While studies have shown that any masticatory activity can raise pH, there is a need to quantify the specific advantage offered by bicarbonateadded formulations compared to standard sugar-free gums. This study aims to evaluate the effect of chewing bicarbonate-containing gum on salivary pH over time to determine its clinical utility in caries prevention.

Methodology

Study Design and Setting

The present study was a 3-arm, parallel-group, randomized controlled trial conducted in the Department of Public Health Dentistry of M.A. Rangoonwala College of Dental Sciences and Research Centre, Pune.

Study Participants

Systemically healthy adults aged 20–25 years with normal salivary flow rate, without oral/dental disease, not wearing any intraoral appliances, and not taking any medications that interfere with salivation were recruited for the study. Participants with systemic diseases, those taking medications affecting salivary flow, smokers, or those with recent dental procedures and active periodontal disease were excluded to maintain internal validity. All participants signed a provided informed consent prior to participation. Participants were instructed not to eat or drink anything for 1 hour before the study conduction.

Grouping

Group 1 (n=20): Control group (No intervention).
Group 2 (n=20): Bicarbonate-containing chewing gum.
Group 3 (n=20): Ordinary (sugar-free) chewing gum.

Sample Size

This randomized controlled trial included 60 participants, divided into 3 groups. The sample size was calculated based on a comparison of the mean salivary pH between three groups using one-way ANOVA. The formula used was:

$n=2\sigma^2 (Z_{\alpha/2}+Z_{\beta})^2 / d^2$

Randomization and Allocation Concealment

Participants were randomly allocated into three groups using a simple randomization by lottery method to ensure unbiased allocation. Allocation concealment was achieved using sequentially numbered, opaque, sealed envelopes (SNOSE technique). Each envelope contained the group assignment and was opened only during the intervention. Blinding was maintained at the participant level, where participants were unaware of the chewing gum administered, as well as at the examiner level (double blinding).

Study Procedure

Appointments for sample collection were scheduled in the morning between 8:30 and 10:00 am to minimise the influence of daily variations in salivary composition and pH. Upon arrival, participants were instructed to remain seated and relaxed before the procedure. An unstimulated whole saliva sample of approximately 6-8mLwas first collected from each participant (spitting method) to establish a baseline salivary pH measurement. Unstimulated saliva was collected by asking the participants to allow saliva to accumulate naturally in the mouth and then expectorate into a sterile collection container without chewing or stimulation.

Following baseline saliva collection from all three groups, two groups were subjected to chewing gum. Participants were given a single pellet of each gum, and allowed to chew them for 2 minutes at their own pace. The saliva was then collected in a sterile container immediately after 2 minutes of chewing. Subsequently, saliva samples were collected at 5,10,15 and 20 minutes interval for all three groups to monitor changes in salivary pH over time.

Throughout the study, the participants were instructed not to consume any food or beverages to avoid external factors influencing salivary pH changes. To reduce bias, the participants were blinded so that they were unaware of which gum they received. All collected saliva samples were analyzed using a high-accuracy digital pH meter with a precision of 0.01 to ensure reliable measurement of salivary pH changes throughout the study (Fig 1). To ensure an unbiased result the examiner was also blinded.

The results were tabulated and analyzed using a paired t-test and repeated measures analysis of variance (ANOVA). The significance level was set at $p < 0.05$.

Fig 1: Materials used for the study (digital pH meter, sterile container, chewing gum containers)

Results

Table 1: Demographic Characteristics among 3 groups in relation with age and gender

Variable	Group 1	Group 2	Group 3	p-value
Gender (M/F)	10/10	10/10	10/10	>0.05
Mean Age	22.8±1.6	23.1±1.8	22.9±1.7	>0.05

Values are expressed as mean ± standard deviation.

The study population was balanced in terms of gender (10M/10F per group) and age (Mean ~23 years). At baseline, there was no significant difference in pH among groups ($p > 0.05$). (Shown in table 1)

Table 2: Intergroup Comparison of Salivary pH at different time intervals

Variable	Group 1	Group 2	Group 3	p-value
Before	6.51±0.15	6.90±0.18	6.86±0.17	>0.05
Ti	6.49±0.16	7.22±0.17	7.13±0.16	<0.001
T5	6.55±0.14	7.11±0.15	7.01±0.14	<0.001
T10	6.60±0.13	7.00±0.14	6.93±0.13	<0.001

Values are expressed as mean ± standard deviation; intergroup comparison performed using one-way ANOVA; $p < 0.05$ considered statistically significant.

This study evaluated the effect of different chewing gum formulations on salivary pH at various time intervals. At baseline (Before), there was no statistically significant difference in salivary pH among the three groups ($p > 0.05$),

indicating that the groups were comparable prior to the intervention.

In the intergroup comparison, a statistically significant difference in salivary pH was observed at all post-intervention time intervals (Ti, T5, and T10) ($p < 0.001$). Group 2 (bicarbonate gum) demonstrated the highest increase in salivary pH immediately after use (Ti), followed by Group 3 (ordinary gum**),** while Group 1 (no gum) showed minimal change. This indicates that chewing gum, particularly bicarbonate-containing gum, has a significant effect on elevating salivary pH. (Shown in table 2)

Table 3: Intragroup Comparison (Group 1) at different time intervals

Time	Mean±SD	p-value
Before	6.51±0.15	—
Ti	6.49±0.16	>0.05
T5	6.55±0.14	>0.05
T10	6.60±0.13	>0.05

paired t-test; $p<0.05$

Table 4: Intragroup Comparison (Group 2) at different time intervals

Time	Mean±SD	p-value
Before	6.90±0.18	—
Ti	7.22±0.17	<0.001
T5	7.11±0.15	<0.001
T10	7.00±0.14	<0.001

paired t-test; $p <0.05$

Table 5: Intragroup Comparison (Group 3) at different time intervals

Time	Mean±SD	p-value
Before	6.86±0.17	—
Ti	7.13±0.16	<0.001
T5	7.01±0.14	<0.001
T10	6.93±0.13	<0.001

paired t-test; $p< 0.05$

In the intragroup comparison, Group 1 (no gum) did not show any statistically significant change in salivary pH across all time intervals ($p > 0.05$), suggesting that absence of stimulation does not influence salivary pH significantly. In contrast, both Group 2 and Group 3 exhibited a statistically significant increase in salivary pH at all post-intervention time points compared to baseline ($p < 0.001$). The increase was more pronounced and sustained in the bicarbonate gum group. (shown in table 3,4,5)

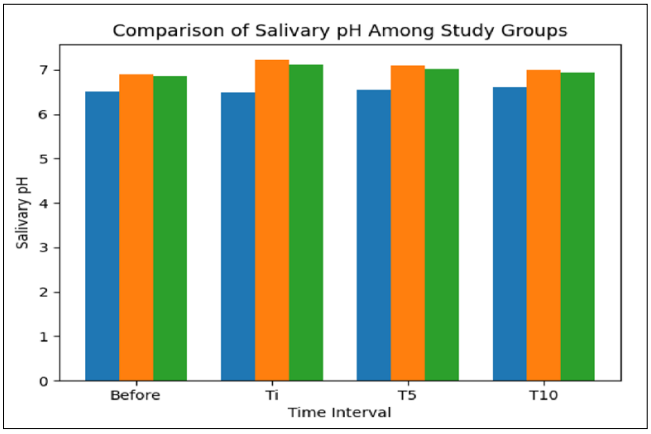

Fig 2: Bar graph showing comparison of salivary pH among study groups at different time intervals

The ANOVA results further confirmed a highly significant difference among the groups ($p < 0.001$), indicating that the type of chewing gum plays a crucial role in altering salivary pH.

Post hoc analysis using Tukey's test revealed that the difference between Group 1 and Group 2, as well as between Group 1 and Group 3, was highly significant ($p < 0.001$). Additionally, a statistically significant difference was observed between Group 2 and Group 3 ($p < 0.05$), indicating that bicarbonate gum is more effective than ordinary gum in increasing salivary pH.

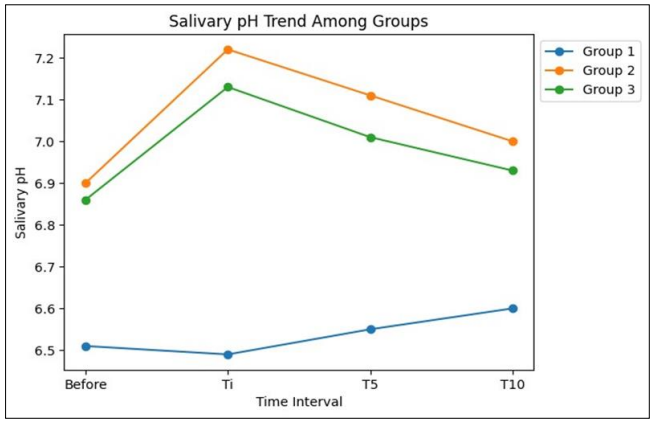

Fig 3: Line graph showing trend of salivary pH among study groups over time

Overall, the findings of the study suggest that chewing gum significantly increases salivary pH, with bicarbonate-containing gum showing the greatest effect, followed by ordinary gum, while no gum shows negligible change.

Intergroup Differences

A highly significant difference ($p < 0.001$) was observed at all postintervention intervals. Group 2 (Bicarbonate) consistently showed the highest pH, followed by Group 3.

Group 1 (Control): Showed no significant change from baseline ($p > 0.05$).

Group 2 (Bicarbonate): pH rose significantly from 6.90±0.18 to 7.22±0.17 at T_i ($p < 0.001$).

Group 3 (Ordinary sugar free): pH rose significantly from 6.86± 0.17 to 7.13 ± 0.16 at T_i ($p < 0.001$).

The ANOVA and post hoc analysis confirmed that the bicarbonate gum (Group 2) was statistically superior to ordinary gum (Group 3) in elevating pH ($p < 0.05$).

Discussion

This clinical trial indicates that while standard mastication increases salivary pH, the inclusion of exogenous sodium bicarbonate enhances this effect. The finding that Group 2 produced the most substantial increase in salivary pH aligns with observations by Bellal *et al*. (2016) [6], who reported that bicarbonate-formulated oral hygiene agents rapidly raise intraoral pH and reinforce the saliva's buffering matrix [6]. The present study confirms that while mechanical stimulation alone increases pH, chemical augmentation with bicarbonate delivers a superior alkalizing effect. Group 2 reached a mean peak pH of 7.22 immediately following the chewing period. This matches the established patterns described by Dawes and Kubieniec (2004) [7], who showed that stimulated saliva contains a naturally higher baseline

bicarbonate level than unstimulated fractions. This phenomenon is enhanced when external bicarbonate is introduced via a delivery vehicle [7].

Throughout all post-treatment intervals, Group 2 consistently outperformed Group 3 ($p < 0.05$). This indicates that the sodium bicarbonate released from the gum matrix introduces an immediate chemical buffer that surpasses the capacity of stimulated saliva alone. These observations parallel those of Kopito *et al*. (2008) [8], who confirmed that bicarbonate-infused gums neutralize plaque acids more efficiently than standard non-bicarbonate options [8].

Furthermore, our results showed that, by $T_{10,}$ the pH began to decline slightly, but remained significantly higher than baseline in both gum groups. This sustained effect is crucial for clinical relevance. Unlike the study by Dehghan *et al*. (2015) [9], which examined mouthwashes and found that pH returned to baseline within 15–45 minutes, our study highlights the dynamic, immediate recovery phase (T_i to T_{10}), during which the risk of demineralization is most acute following an acid challenge [9]. Similar research has shown that when gum is chewed following a sucrose rinse, it initiates a pronounced pH recovery, often neutralizing plaque acids within the first few minutes of chewing (Imfeld *et al*., 1995) [10]. Other additives, such as urea, have also been investigated for their alkalizing potential; however, studies suggest that while ureacontaining gums can enhance pH rise, bicarbonate-based formulations often show greater immediate consistency in raising salivary pH levels (Smith *et al*., 2004) [11].

A major strength of this trial is its randomized, double-blind allocation and the use of a highprecision digital pH meter, which avoids the subjective color matching required by standard pH strips. A limitation of this study is its narrow demographic focus (young adults). A study with different age groups is recommended. As noted by Polyakova *et al*. (2020) [12], whole saliva flow rates and specific chemical concentrations fluctuate markedly with age and general health status, which could limit the generalizability of these insights to older populations[12]. Finally, while alternative natural or herbal additives can raise oral pH as documented by Manikandan *et al*. (2021) [13], sodium bicarbonate remains an affordable**,** stable, and highly effective option for commercial consumer formulations.

Conclusion

The use of bicarbonate-containing chewing gum results in a statistically significant and more pronounced increase in salivary pH compared to ordinary chewing gum and no-gum controls. This makes it an effective adjunct in oral hygiene regimens, particularly for individuals at high risk of caries or those frequently exposed to acidic diets.

Reference

1. Stephan RM. Intra-oral hydrogen-ion concentrations associated with dental caries activity. J Dent Res,1944:23(4):257-66.
2. Humphrey SP, Williamson RT. A review of saliva: Normal composition, flow, and function. J Prosthet Dent,2001:85(2):162-9.
3. Ship JA, *et al*. Effects of chewing gum on salivary flow rates and pH. Oral Surg Oral Med Oral Pathol Oral Radiol Endod,2002:94(2):175-9.
4. Maltz M, *et al*. Effect of a bicarbonate-containing gum on salivary pH and flow rate. Braz Oral Res,2006:20(2):120-5.
5. Anderson LA, Orchardson R. The effect of chewing bicarbonate containing gum on salivary flow rate and pH in human. Arch Oral Biol,2003:48(3):201–204.
6. Bellal S, *et al*. Effect of bicarbonate-containing products on salivary pH and buffering capacity. Journal of Oral Health, 2016.
7. Dawes C, Kubieniec K. The effects of prolonged gum chewing on salivary flow rate and composition. Arch Oral Biol,2004:49(8):665-9.
8. Kopito R, *et al*. Effects of sodium bicarbonate chewing gum on salivary pH and plaque acid neutralization. J Dent Res, 2008, 87(Spec Iss B).
9. Dehghan M, *et al*. Effect of different mouthwashes on salivary pH after an acidic challenge. J Clin Exp Dent,2015:7(1):16–20.
10. Imfeld T, Birkhed D, Lingström P. Effect of urea in sugar-free chewing gums on pH recovery in human dental plaque evaluated with three different methods. Caries Research,1995:29(3):172–180.
11. Smith CA, Higham SM, Smith PW, Verran J. The effect of chewing urea-containing gum on plaque acidogenic and alkaligenic parameters. Caries Research,2004:38(2):124–129.
12. Polyakova M, *et al*. Evaluation of the neutralizing effect of various rinsing solutions. Int J Dent, 2020.
13. Manikandan R, *et al*. Comparison of salivary pH after rinsing with chlorhexidine and herbal mouthrinses. J Pharm Bioallied Sci,2021:13(1)S456-9.