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Effects of Carbonated Drink & Fruit Juice on Salivary pH of Children: An in Vivo Study

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Abstract

Introduction: Urbanization and economic development has resulted in rapid changes in diet and lifestyles. Though people are aware of the deleterious effect of carbonated beverages and fruit juices on the teeth, they do prefer to consume these things. Purpose of the study is to assess the changes in salivary pH at different intervals after consumption of carbonated drink & fruit juice.

Material & Method: Thirty nine children age 8 to 12 years were assessed for changes in salivary pH at different interval after consumption of carbonated drink & fruit juice on two different days. Changes in salivary pH were checked at different interval of immediate, 5 minutes, 10 minutes, 15 minutes & 30 minutes.

Result: Present study shows higher fall in immediate salivary pH after mixed fruit juice when compared to cold drink. Immediate salivary pH value ranged from 3.21 to 6.86 with a mean value of 5.47±0.78 (SD) for cold drink where for mixed fruit juice it was 3.26 to 6.53 with a mean value of 4.89±0.97 (SD).

Conclusion: Present study suggested that there is a decline in the salivary pH after consumption of both types of beverage. There was higher fall in the salivary pH in the case of fruit juice when compared to carbonated drink. Regular consumption of such drinks should be discouraged.

Key Words: Salivary pH, Digital pH Meter, Dental Erosion, Caries.

Introduction:

The concept of health has prevailed for centuries and the dietary habits are apparently changing as well. Urbanization and economic development have resulted in rapid changes in diet and lifestyles. The diet we are consuming has become more refined with increased access to readymade drink.[1] Also there has been a substantial increase in consumption of carbonated beverage & fruit juices.[2] Now a day's "healthy eating" is considered to be important. Though people are aware of the deleterious effect caused by carbonated beverages and fruit juices on the teeth, they do prefer to consume these things.[3] The literature reveals that parent`s influence, peer pressure, diet fallacies, pleasure and taste are the reasons that lead children to consume these drinks.[2,4] Saliva plays an important role in maintaining the integrity of teeth by way of its buffering action and controlling the demineralisation and promoting remineralization, occurring continuously at the enamel surface.[5] The pH value, the calcium and phosphate content of a drink or food stuff are important factors responsible for the erosive attack and formation of dental caries.[2,6] It also is known that the plaque pH goes from acidic to normal (or the resting level) within a few minutes and depends on the presence of saliva. This is primarily due to the carbonate and phosphate pH buffering agents in the

saliva.[5] The production of acid by bacteria in such close proximity to the tooth surface would mean that on consumption, the enamel demineralization could occur, hence their acidogenic and cariogenic potential.[7,8] The erosive effect of fruit juices has been recognized for a long time as evident in the studies of Darby (1892) [9] and W.D. Miller (1907)[10] who reported tooth decalcification due to excessive fruit juice consumption.

The soft drinks are thought to cause damage to the teeth because of two properties – first, the low pH and titrable acidity of some drinks can cause erosion on the enamel surfaces[11,12] and secondly the fermentable carbohydrate in drinks is metabolized by plaque micro-organisms to generate organic acids in the dental plaque and saliva, resulting in demineralization and leading to dental caries.[13] Packaged fruit juices are sweeter having higher sugar content to enhance their taste and carbonated beverages have higher acidic content which causes demineralization of enamel tooth surface.[14]

There has been a recent growth in the number of carbonated drinks and fruit juices in the Indian market possibly due to new production companies and the expansion of established ones. This, coupled with the rise in consumption of fruit juices especially among children was our chief concern. A grey area still exists with not enough literature on these products on oral health. Hence this study was conducted to assess the acidogenic potential of cold drink & fruit juice.

Material & Method:

The present study was conducted on thirty nine children with age 8 to 12 years. Subjects reporting to the outpatient department of the Teerthankar Mahaveer Dental College & Research Centre, Moradabad was assessed. Ethical clearance was obtained from Teerthankar Mahaveer University, Moradabad & written informed consent was taken from the parent of each patient.

Test drink:-

Two test drink used here

1. Cold-drink (Mirinda) ®
2. Mixed fruit juice (Tropicana) ®

An instrument used: - bench type pH meter (HANNA instrument, USA) having an accuracy of ± pH 0.01

Subject selection: Following were the inclusion & exclusion criteria.

Inclusion criteria:

1. All subjects who were medically fit and healthy.
2. Subjects who had DMFT & dmft less than 2.
3. All subjects who were having a strictly vegetarian diet.

Exclusion criteria:

Exclusion criteria will comprise of any:-

1. Subject having any history of systemic diseases & Infection diseases.
2. Subject suffering from any congenital diseases.
3. Subject with History of any antibiotic 2 months prior to the study.

The children were assessed on the first day for dental caries through dmft/DMFT index& dietary history was taken. The test was started from second appointment, so as to reduce any effects of anxiety that might have had on a child visiting the dentist for the first time. For saliva collection, each child was instructed not to eat or drink anything for up to 2 hours preceding the appointment. Each patient was given a simple explanation as to the nature and reasons for the test before collecting saliva samples. Each subject was asked to come for 3 days regularly for the test, for one of the products on each day.

- ✓ Day1: dietary history, DMFT/ dmft
- ✓ Day2: assessment of salivary pH changes with cold drink (group1)
- ✓ Day3: assessment of salivary pH changes with mixed fruit juice (group2)

The salivary pH was of both unstimulated and stimulated saliva was measured. Unstimulated pH was measured at the same time of the day. The pH meter was calibrated each day prior to measurement for accurate reading. The accuracy of the pH meter was checked at regular intervals to ensure that readings were correct. For the collection of unstimulated saliva, the children were asked to sit

comfortably. After the baseline score was recorded, beverages were tested on all children on two subsequent days. The children were asked to drink the beverages from a glass without using a straw. After intake of different beverages & eatables immediately salivary pH were measured. Salivary pH was measured at the interval of 5, 10, 15 & 30 minutes later.

To measure the pH of saliva, saliva was collected in disposable spoon, to avoid any contamination of sample. The pH-sensitive electrode was dipped in sample for the reading. The digital reading was allowed to stabilize for a few seconds and the pH reading was taken. In between readings, the electrode was cleaned with distilled water and placed in a standard solution of pH 7·0. This ensured stable readings and provided a constant check on the drift. The pH was measured immediately after collection.

Results:

The observations have been discussed in two parts:

a) **Within group changes**
b) **Intergroup differences**

i) Group I: Cold Drink

At baseline salivary pH values ranged from 6.18 to 7.65 with a mean value of 6.99±0.36 (SD). Immediately after intake of cold drink, salivary pH values ranged from 3.21 to 6.86 with a mean value of 5.47±0.78 (SD). After 5 minutes of intake of cold drink, salivary pH values ranged from 5.21 to 7.48 with a mean value of 6.52±0.54 (SD). After 10 minutes of intake of cold drink, salivary pH values ranged from 5.18 to 7.57 with a mean value of 6.46±0.53 (SD). After 15 minutes of intake of cold drink, salivary pH values ranged from 5.63 to 7.53 with a mean value of 6.54±0.46 (SD). After 30 minutes of intake of cold drink, salivary pH values ranged from 5.88 to 7.7 with a mean value of 6.86±0.45 (SD). (Table No. 1)

ANOVA was used to evaluate the effect of time on salivary pH after intake of Cold drink. In evaluating the effect of time on the salivary pH levels after intake of cold drink, it was found to be significant statistically ($F=68.404$; $p<0.001$). A maximum mean difference was observed between baseline and immediately after intake of cold drink while the minimum difference was observed between 5 minutes and 15 minutes after intake of cold drink. (Table No. 2)

ii) Group II: Mixed Fruit Juice

At baseline salivary pH values ranged from 6.27 to 7.76 with a mean value of 6.97±0.39 (SD) immediately after intake of Mixed Fruit Juice, salivary pH values ranged from 3.26 to 6.53 with a mean value of 4.89±0.97 (SD). After 5 minutes of intake of Mixed Fruit Juice, salivary pH values ranged from 0.76 to 7.29 with a mean value of 6.35±1.07 (SD). After 10 minutes of intake of Mixed Fruit Juice, salivary pH values ranged from 5.26 to 7.48 with a mean value of 6.43±0.53 (SD). After 15 minutes of intake of Mixed Fruit Juice, salivary pH values ranged from 5.26 to 7.48 with a mean value of 6.43±0.53 (SD). After 30 minutes of intake of Mixed Fruit Juice, salivary pH values ranged from 5.33 to 7.54 with a mean value of 6.59±0.51 (SD). (Table No. 1)

ANOVA was used to evaluate the effect of time on salivary pH after intake of Mixed Fruit Juice**.** In evaluating the effect of time on the salivary pH levels after intake of Mixed Fruit Juice, it was found to be significant statistically ($F=59.599$; $p<0.001$). A maximum mean difference was observed between baseline and immediately after intake of Mixed Fruit Juice while the minimum difference was observed between 5 minutes and 10 minutes after intake of Mixed Fruit Juice. (Table No. 3)

Between Group Differences

At the baseline mean salivary pH levels in different groups ranged from 6.99 to 6.97. Immediately after intake of beverages, Groups I and II showed a sharp decline in pH. However, from 5 minutes interval onwards, all the groups showed a tendency to return towards baseline values. This return was early and sharp in Groups I, II. (Graph No. 1)

At baseline, none of the between group comparisons were significant statistically. At immediately & 5 minutes after the intake interval, they were significant statistically. At 10 minutes, 15 minutes & 30 minutes post intake interval no differences were significant statistically. (Table No. 4)

Table No. 1: Shows Mean pH Values of Two Groups at Different Time Intervals

SN	Time Interval	Group I (n=39)		Group II (n=39)	
		Mean	SD	Mean	SD
1	Baseline	6.99	0.36	6.97	0.39
2	Immediate	5.47	0.78	4.89	0.97
3	5 min	6.52	0.54	6.35	1.07
4	10 min	6.46	0.53	6.43	0.53
5	15 min	6.54	0.46	6.59	0.51
6	30 min	6.86	0.45	6.87	0.46

Table No. 2: Shows Pairwise Comparison of Mean pH Levels at Different Time Intervals for Cold Drink

Comparison	Mean Difference	SE	Significance	95% Confidence Interval for Difference	
				Lower bound	Upper bound
Baseline vs Immediate	1.518	0.129	<0.001	1.257	1.779
Baseline vs 5 min	0.471	0.078	<0.001	0.312	0.629
Baseline vs 10 min	0.534	0.065	<0.001	0.401	0.666
Baseline vs 15 min	0.455	0.051	<0.001	0.352	0.557
Baseline vs 30 min	0.126	0.046	0.009	0.033	0.219
Immediate vs 5 min	-1.047	0.118	<0.001	-1.286	-0.808
Immediate vs 10 min	-0.984	0.126	<0.001	-1.239	-0.729
Immediate vs 15 min	-1.063	0.125	<0.001	-1.317	-0.809
Immediate vs 30 min	-1.391	0.141	<0.001	-1.678	-1.105
5 min vs 10 min	0.063	0.065	0.340	-0.069	0.195
5 min vs 15 min	-0.016	0.080	0.843	-0.177	0.145
5 min vs 30 min	-0.344	0.092	0.001	-0.530	-0.158
10 min vs 15 min	-0.079	0.053	0.145	-0.187	0.029
10 min vs 30 min	-0.407	0.067	<0.001	-0.542	-0.272
15 min vs 30 min	-0.328	0.040	<0.001	-0.409	-0.247

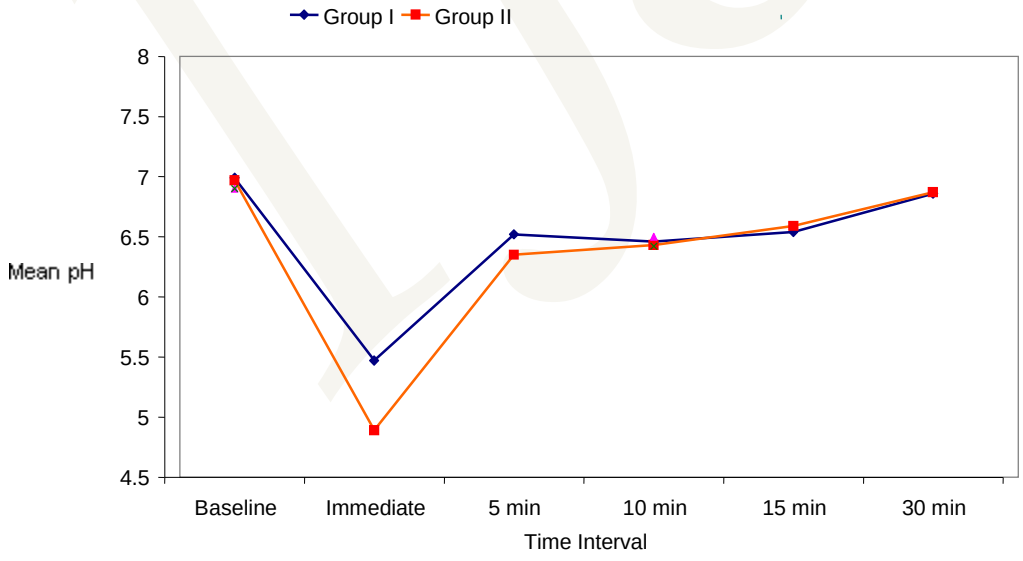
Table No. 3: Shows Pairwise Comparison of Mean pH Levels at Different Time Intervals

Comparison	Mean Difference	SE	Significance	95% Confidence Interval for Difference	
				Lower bound	Upper bound
Baseline vs Immediate	2.077	0.170	<0.001	1.733	2.421
Baseline vs 5 min	0.624	0.169	0.001	0.281	0.967
Baseline vs 10 min	0.541	0.063	<0.001	0.414	0.668
Baseline vs 15 min	0.376	0.059	<0.001	0.256	0.496
Baseline vs 30 min	0.095	0.060	0.119	-0.026	0.216
Immediate vs 5 min	-1.453	0.216	<0.001	-1.891	-1.016
Immediate vs 10 min	-1.536	0.183	<0.001	-1.907	-1.165
Immediate vs 15 min	-1.701	0.173	<0.001	-2.052	-1.350
Immediate vs 30 min	-1.982	0.174	<0.001	-2.334	-1.630
5 min vs 10 min	-0.083	0.163	0.613	-0.413	0.247
5 min vs 15 min	-0.248	0.160	0.129	-0.571	0.075
5 min vs 30 min	-0.529	0.131	<0.001	-0.795	-0.263
10 min vs 15 min	-0.165	0.034	<0.001	-0.233	-0.096
10 min vs 30 min	-0.446	0.065	<0.001	-0.578	-0.314
15 min vs 30 min	-0.281	0.054	<0.001	-0.391	-0.171

Table No. 4: Between Group Comparison of Mean Salivary pH Levels at Different Time Intervals (Tukey HSD test)

Group	Mean Difference	SE	"p" Value
Baseline			
I vs II	0.020	0.084	0.999
Immediate			
I vs II	0.579	0.136	<0.001
5 min			
I vs II	0.174	0.146	0.757
10 min			
I vs II	0.027	0.119	0.999
15 min			
I vs II	-0.058	0.117	0.987
30 min			
I vs II	-0.011	0.108	1.000

Graph No. 1: Shows Changes in Salivary pH After Cold Drink & Fruit Juice



Discussion:

A vast amount of laboratory research has been carried out on the effects of carbonated beverages in relation to dental caries and erosion,[15] but very much less has been done on humans and there is a paucity of data. Hence, a randomized comparative clinical trial was done to know the salivary pH changes and buffering capacity of saliva after consumption of cold drink, mixed fruit juice in children.

In the present study glass combination electrode was used for assessing salivary pH as it is an established, sensitive and accurate methodology. Usually various colorimetric methods have been employed to determine the pH of saliva. The electronic method with the glass electrode is preferable because of its accuracy.[16] In the present study there were two groups, cold drink & fruit juice. Our study showed a drop in salivary pH after consuming cold drink and fruit juice with more drop in pH in juice group when compared to cold drink users.

In the present study, there was a drop in mean salivary pH immediately after consuming cold drinks to 5.47±0.78 from baseline pH 6.99±0.36. There was a slight increase in the pH after 5 minutes (6.52±0.54) and decrease in pH after 10 minutes (6.46±0.53). After 20 minutes the pH started to rise (6.54±0.46) and a sustained rise was seen after 30 minutes (6.86±0.45) trying to bring back to baseline pH. The time variations with salivary pH were found to statistically significant. When pairwise comparisons were done there was a significant difference obtained in between all the timings except between 5 and 10, 15 minutes as well as between 10 minutes and 15 minutes.

In present study results of drop in pH immediately after consuming carbonated beverage and after 5 minutes are similar to the study reports of Lehl G et al 1993[17], R. Moazzez et al 2000[18], Sánchez and M. V. Fernandez in 2003[19], and Sardana V et al 2012.[20] The carbonated beverages contain phosphoric acid, citric acid and maleic acid [21] which may be the reason for decreased salivary pH as shown in this study and enamel demineralization resulting in dental erosion. Presence of acids in the carbonated beverage would have caused the immediate decrease in salivary pH which may have rendered the buffering capacity of saliva to be slow.

The present study showed a drastic drop (4.89±0.97) in salivary pH from baseline (6.97±0.39) immediately after consumption of mixed fruit juice. After 5 minutes the pH recovered (6.35±1.07) and this recovery was sustained throughout from 10, 20 and 30 min (6.43±0.53, 6.59±0.51 and 6.87±0.46 respectively). The time variations with salivary pH showed a significant difference (df =5, F= 59.599, p = <0.001, S). Pair wise comparisons showed a significant variation in between all-time intervals except baseline to 30 minutes and 5 minutes to 10, 15 minutes.

This results are in concurrence with the study results of Sabyasachi Saha et al (2001), were in Apple and guava packed juices were used for the study and showed pH changes from baseline to 30 min ranging from 7.17 to 6.58, 7.08, 7.31, 7.31. [22] Birgül Azrak et al (2003) in Germany among children with mean age of 4.4 years showed results similar to our study by detecting the pH difference from baseline to 25 minutes (Δ PH = - 0.20 at baseline, -0.50 at 5 minutes, -0.24 at 10 minutes, -0.16 after 15 minutes, and -0.01 after 25 minutes bringing back the pH to baseline value) after consuming packaged apple juice.[23] Similarly, Lata Kiran Banan and Amitha M Hegde in 2005 conducted a study on 10-12 year old children in Mangalore using fresh fruit juices (Grape, Orange and Pineapple) which showed a maximum percentage reduction in salivary pH within 5 minutes of consumption of these fruit juices and a multivariate analysis of various fresh fruit juices, at different time intervals showed significant difference ($p < 0.05$).[2] Another study showed median Δ pH of whole saliva at baseline (-0.56) and after consumption of orange juice at 5 minutes (-0.41), 10 minutes (-0.26), 15 minutes (-0.13), 25 minutes (-0.04).[21] It was also reported that fruit juices were 10 times more destructive than the whole fruit.[24]

Maximum pH decrease after intake of different beverages is an important consideration in dental erosion, as apatite dissolution increases in the lower pH range.[25] The probable reason for the immediate

drop in salivary pH in our study could be that the intrinsic acidity of packed fruit juices rendered it more able to combat salivary buffers. The greater the pH fall can also be attributed to prolonged period of consumption of these fruit juices (approximately 5 minutes), which could expose the teeth to dangerously low levels of pH as the acid and sugar is held for a prolonged period in contact with the teeth.[1] There may be a prolonged fall in the oral cavity pH due to the increased buffering capacity of fruit juices & fruit based drinks. Though the amounts of acid beverages normally consumed by children may be insignificant, the presence of immature enamel, inadequate neuromuscular coordination and inability to clear the retentive substrate, along with the deleterious methods of consumption, makes them susceptible to dental erosion.[26]

Acidified sugar containing drinks has shown to be cariogenic and erosive in rats. Beverages, especially fruit juices, can contain a variety of acids that are likely to damage the teeth.[14] Juices for example contain several sugars and non-volatile organic acids.[28] Fructose and glucose are considered to be less cariogenic than sucrose, but the dental plaque, formed in the presence of a mixture of these two sugars also leads to a decrease in the micro-hardness of the enamel. Packaged juices contain high amount of added sugar i.e., sucrose, which is highly cariogenic.[29]

Theoretically, the erosive potential of a soft drink (carbonated beverage or fruit juice) must be dependent upon the immediate effect of the drink & time taken for its clearance on the tooth, the drinking method, the protective effect of saliva, the amount of residual drink after swallowing, the actual amount of beverage consumed and the frequency of consumption (that is, if small ships are taken at frequent intervals or the entire bottle is consumed quickly). A single acidic attack is of minor importance but if repeated, the ability of saliva to deal with the acid attack may decrease. Hence, the main concern is about the frequent use of soft drinks over time. If the challenge is frequent enough and there are few or no protective factors this may be aggressive as in caries susceptible people.

Between group comparison:

In the present study the group consuming commercially available packed mixed fruit juices showed a maximum drop in salivary pH (4.89), immediately after consumption when compared to the carbonated beverage (5.47), followed by a gradual recovery within 30 minutes of study. This greater drop could be attributed to the relatively lower intrinsic pH of commercially available fruit juices. Similar results have been shown by Lata Kiran *et al*, 2005[1], Birgül Azrak et al (2003),[23] G. A. Sánchez and M. V. Fernandez[19] in 2003 and Birgül Azrak et al (2008).[21] The type of acid used may possibly explain the ability of the fruit juices to resist pH change as observed in a study where phosphoric acid was the only acid in the carbonated beverages while citric acid and ascorbic acid predominated in the fruit juices along with high sugar content in fruit juices leading to high titrable acidity. Surprisingly a study by West, N.X., et al 2008 has shown that citric acid caused far more erosion than phosphoric acid. Other important contributors were possibly the concentration of the acids and additive ingredients.[30]

In the present study, clinical trial was carried out using only one type. However more studies with larger sample sizes with the above products and individual ingredients of these products with control group should be conducted. We have known there was a lesser pH drop when straw is used for consumption. Beverage intake cannot be standardized. Although the erosion and caries process have contrasting histological appearance, these conditions occurring simultaneous can have undesirable effects on dental hard tissue. As dental professionals we need to educate our patients about the consequences of consumption of such drinks and provide solutions to minimize the risk.

Conclusion:

Present study suggested that there is a decline in the salivary pH after consumption of both types of beverage. There was higher fall in the salivary pH in the case of fruit juice when compared to carbonated drink. Regular consumption of such drinks should be discouraged.

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