# The Effect of Different Methods of Drinking a Carbonated Beverage on the Ph of Dental Plaque: An *In Vivo* Study

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**Purpose:** Fizzy drinks are known to be erosive or cariogenic, but little is known about the ways of reducing their harmfulness by altering the method of drinking. The purpose of this study was to assess the changes in plaque pH, at different time intervals *in vivo* after consuming a carbonated beverage (sprite, pH = 2.98) with plastic glass, straw and directly from bottle.

**Design:** A clinical study.

**Material and Methods:** Eighteen subjects aged 18–25 years were recruited for the study and were divided randomly into three groups, six in each (group A- plastic glass, B- straw and C- directly from bottle) after the salivary pH was measured. Subjects were requested to refrain from brushing for 24 hours prior to the study. Collection of pooled plaque was done before and after consuming the drink at five, 10-, 20- and 30-minute intervals. Plaque pH was assessed by glass combination electrode. ANOVA and post hoc Tukey's test was used for statistical analysis.

**Results:** Highest mean pH drop (5.29) was recorded when consumed with plastic glass at all time intervals. There was a significant difference between group A and B at 5 min and 10 min ($P < 0.05$). However, no difference was seen between group B and C, A and C ($P > 0.05$).

**Conclusions:** The use of a straw and direct consumption of beverage from the bottle could limit harmful effects on dentition.

**Key words:** dental erosion, carbonated beverages, plaque, pH, cariogenic diet

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The beverage market has in recent years seen drastically increased consumption of aerated drinks (8.4 billion bottles in 2003). Teenagers and children, whom many fizzy drinks are marketed towards, are among the largest consumers and account for 65% of total sales (Ashe and Read, 1987). Literature reveals that parents' influence, peer pressure, diet fallacies, pleasure and taste are reasons that lead children to consume these drinks (Lussi et al, 1995; May and Waterhouse, 2003). Fizzy drinks contain aspartame, phosphoric acid, citric acid, maleic acid, phosphates, sugar, caffeine, tap water and fluoride (Duggal et al, 1995). These 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 (Smith and Shaw, 1987; Greenby et al, 1990) and, secondly, the fermentable

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carbohydrate in drinks is metabolised by plaque micro-organisms to generate organic acids in the dental plaque, resulting in demineralisation and leading to dental caries (Grobler and Jenkins, 1985).

Although these fizzy drinks are known to be erosive or cariogenic, little is known about possible ways of reducing their harmfulness by altering the method of drinking. The manner in which these dietary acids are introduced into the mouth (gulping, rinsing, use of straw) will affect which teeth are contacted by erosive challenge and possibly the clearance pattern (Millward et al, 1994; Edwards et al, 1998). There have been very few studies in the literature that have looked at the effect of different drinking methods and to recommend the best method to reduce harmful effects on dentition. Edgar, Bibby and Mundorff (1975) reported a more profound fall in pH after a carbonated beverage was used as a rinse for one minute than after normal drinking. Birkhed (1984) showed that drinking the product either from a glass or with a straw resulted in a less pronounced pH fall than when the subjects rinsed with it. A study by Grobler et al reported that drinking the product either from a glass or a straw resulted in smaller pH drop than a mouth rinse. In younger children, where carbonated drinks have a potential to be misused, emphasis should be on correct and safer ways of consumption.

Hence, a study was conducted with the objectives to record the baseline pH of plaque and to record the changes in plaque pH after consuming a carbonated beverage at different time intervals with a plastic glass, straw and directly from the bottle.

## MATERIALS AND METHODS

### *Test Drink*

Sprite, a carbonated beverage, at room temperature with a pH of 2.98 was used as the test drink.

### *Subject Selection*

Initially 30 subjects were selected from KLE'S College of Physiotherapy, Belgaum, on the criteria based on the recommendation made at the San Antonio conference on methods for assessing cariogenic potential of foods and beverages (Harper et al, 1986; Curzon and Hefferen, 2001). Subjects with at least 20 teeth present, a minimum DMFS of 12, and whose salivary buffering capacity was less than or equal to 5.5 and subjects healthy without any medication were included in the study. However, only 18 subjects who consented to refrain from oral hygiene practice procedures for 24 hours before the test and to abstain from any food or drink (except water) for eight hours prior to the study were finally recruited. The study was conducted in the Department of Preventive and Community Dentistry, KLE's Institute of Dental Sciences, Belgaum, Karnataka, India, for a period of two weeks in October 2004. It was a single-blind study.

### *Salivary Buffering Capacity*

The salivary pH of stimulated saliva (by paraffin wax) was measured directly using a pH meter (Mayura Autotitrator, AT-91, Mayura analytical PVT Ltd) that was calibrated using buffers of pH 4.01 and 7.01. The accuracy of the pH meter was checked at regular intervals to ensure that readings were correct. To measure the pH of saliva, a 1 ml drop of saliva was dropped onto the pH-sensitive electrode. The digital reading was allowed to stabilise for a few seconds and the pH reading taken. In between readings the electrode was cleaned with a stream of distilled water and placed in a standard solution of pH 7.0. This ensured stable readings and provided a constant check on drift. The pH was measured as soon as possible and not later than 30 minutes after collection.

The final study sample consisted of 18 subjects (10 female and eight male subjects with a mean age of 20.10 $\pm$ 2.37 years) who were randomly divided by lottery method into three groups (six in each). The Group A subjects (n = 6) consumed the drink from a plastic glass. Group B (n = 6) were requested to position the straw (diameter = 3 mm) more posteriorly at the back of mouth near the molars and consume the drink, whereas Group C (n = 6) consumed the drink directly from the bottle. Only one group was studied per day, and the study was carried out in the morning hours (8 am – 10 am).

### *Plaque Sampling and Measurement*

Fosdick et al's (1941) method of plaque sampling and plaque measurement was followed. A pooled sample of plaque was collected each time from buccal, lingual and approximal surfaces of selected teeth, i.e. 16, 22, 36 and 42, with a blunt probe for

**Table 1 Mean plaque pH values, ANOVA and Turkey's Test**

| Comparison of Mean pH levels between three groups and confidence intervals. | | | | | | |
|---|---|---|---|---|---|---|
| Groups | | Baseline | 5 min | 10 min | 20 min | 30 min |
| Group .A | | 6.20 ± 0.06<br>° 6.08 – 6.32 | 5.30 ± 0.13<br>° 5.03 – 5.57 | 5.34 ± 0.19<br>° 4.96 – 5.72 | 5.70 ± 0.19<br>° 5.32 – 6.08 | 5.99 ± 0.19<br>° 5.62 – 6.36 |
| Group .B | | 6.19 ± 0.04<br>° 6.10 – 6.27 | 5.64 ± 0.09<br>° 5.46 – 5.82 | 5.76 ± 0.09<br>° 5.57 – 5.95 | 5.97 ± 0.08<br>° 5.82 – 6.12 | 6.10 ± 0.04<br>° 6.01 – 6.18 |
| Group .C | | 6.19 ± 0.06<br>° 6.07 – 6.30 | 5.60 ± 0.27<br>° 5.05 – 6.14 | 5.69 ± 0.29<br>° 5.11 – 6.27 | 5.79 ± 0.29<br>° 5.22 – 6.36 | 6.04 ± 0.10<br>° 5.85 – 6.24 |
| ANOVA F | | 0.09 | 6.10 | 6.92 | 2.74 | 1.08 |
| P value | | 0.91, NS | *0.01, S | *0.01, S | 0.10, NS | 1.08, NS |
| Diff. between groups. Post-hoc Tukey Test | A-B | NS | *P < 0.05 | *P < 0.05 | NS | NS |
| | A-C | NS | NS | NS | NS | NS |
| | B-C | NS | NS | NS | NS | NS |

* P < 0.05, sig
P > 0.05, not sig
° Confidence intervals

three seconds per collection. Five samples of approximately 1 mg each, representing all the quadrants, was obtained before subjects consumed the drink. This served as baseline data. Plaque was then immediately suspended in 10 microlitres of distilled water in a test tube and pH was measured using a glass combination electrode. Each subject was given 15 ml of Sprite to be consumed in one minute. The plaque was collected from the designated sites at five, 10, 20 and 30-minute intervals, and the pH was recorded using the glass combination electrode.

### *Calibration of the Equipment*

The measurement of plaque pH was performed using Autotitrator, AT-91 (Mayura analytical PVT Ltd), which was calibrated with a glass combination electrode using standard buffers of pH 4, 5 and 7. All stabilised readings were recorded. Calibration was performed after each 60-minute run. The above was standard practice for all measurements, and a single examiner who was blinded took all readings.

Informed consent was obtained from the subjects and approval for the study was obtained from the KLE'S Research and Ethical Committee, Belgaum.

### *Statistical Analysis*

The mean standard deviation was calculated. ANOVA and the Post-Hoc Tukey's test was used to statistically analyse the data. A Stephan curve was also plotted.

## RESULTS

The mean DMFS and the mean salivary pH of the subjects was 9.88 ± 1.37 and 5.35 ± 0.184 respectively. Table 1 shows that the drop in plaque pH from the resting value when the Sprite was consumed with a straw was the lowest (0.55), followed by drinking directly from bottle (0.59), with the largest drop being when the Sprite was consumed from a plastic glass (0.90). There is a drastic drop in

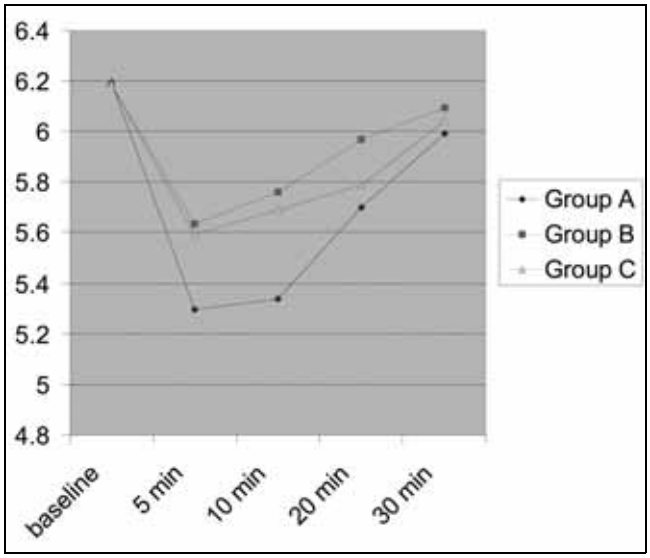


**Fig 1** Stephan curve: Plaque pH curve.

plaque pH at five minutes after consuming Sprite from a plastic glass from baseline pH, the drop sustained for five minutes, while the pH drop of group B, and C never reached critical pH. There is a highly significant difference in Group A and Group B at five– (P = 0.01, S) and 10– (P = 0.01, S) minute intervals. However, no difference was observed at 30– (P = 1.08, NS) minute intervals. The Post Hoc test confirmed the significance between Group A and Group B. No significant difference was observed between B and C as well as A and C. The Stephan curve was plotted for Sprite consumed by all three different methods (Fig 1).

## DISCUSSION

In our study all three methods of consuming Sprite led to a fall in plaque pH, with gradual recovery in 30 minutes. It emerged from our study that drinking with a straw lead to a lower plaque pH drop when compared to drinking from a plastic glass and directly from the bottle. This finding is in concurrence with the study reports of Grobler et al (1985), Edwards et al (1996) and Thamassebhi and Duggal (1997). The observed beneficial effect of consuming a drink with use of a straw is probably a reflection of the period of contact between drink and plaque. The drink is less likely to be held in the mouth for a longer period once it has been drawn up through the straw. As the straw would deliver the drink to the back of mouth, it would be swallowed quickly and the contact between the plaque microorganisms and drink is reduced. Use of a straw would reduce the plaque pH fall and, in turn, reduce the demineralisation of teeth (Tahamassebi and Duggal, 1997).

The more pronounced plaque pH fall observed when the drink was consumed from a plastic glass was due to the drink coming in contact with plaque and being retained in a higher concentration on more sites in the mouth for a longer duration, causing increased acid production in the dental plaque. The drop sustained for 10 minutes as shown in the Stephan curve depicts the duration of contact of the drink with plaque. There was not much difference observed between drinking by straw and directly from the bottle. This may be due to the drink being taken to the back of the mouth and lesser duration of contact of the drink with teeth. The acidogenicity and, hence, the cariogenicity is related to both the extent of acid production and the length of exposure to organic acids. A prolonged and frequent use of an acidogenic drink, leading to repeated episodes of low plaque pH, would have the potential of demineralisation (Tahamassebi, and Duggal, 1996).

The human plaque acidity model-working group agreed that the methods of measuring plaque pH would satisfactorily identify non-acidogenic foods. They provide evidence of acidogenic potential of foods under normal conditions. The fall in plaque pH itself has been correlated with the caries increment (Curzon and Hefferen, 2001). The total sugar concentration of most fizzy drinks is usually between 7 – 10% (Birkhed, 1984). Even very low sucrose concentrations of around 0.1 – 1% can cause pH drops below critical pH values. The drink in this study, Sprite, was selected as it is preferred by the majority of the population over other carbonated beverages, as it has less effervescence and the content of pesticide is lower comparatively. It is realised that the present results are based on the harvesting method of measuring plaque pH and may differ from measurements made with an indwelling electrode. As Imfeld (1983) and Birkhed (1984) point out, both methods have advantages and disadvantages. The present study should be considered a pilot study, and further studies with a larger sample size are recommended.

It is difficult to imagine – and would be naïve – that the use of these drinks can ever be stopped completely. In the light of present data, it would ap-

pear that the use of a straw and consuming directly from the bottle could limit harmful effects on dentition (cariogenicity and dental erosion). However, use of straw or bottle must not be seen as a license to consume vast amounts of potentially erosive beverages. Emphasis should still be placed on the need to reduce the frequency of consumption of aerated drinks, especially in children. In conclusion, if carbonated beverages are consumed, then use of a straw and drinking directly from the bottle rather than a glass are recommended.

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