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Erosive effect of carbonated soft drinks on dental enamel

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Abstract : *Laboratory research was conducted to estimate the erosive potential of eight different commercial soft drinks – Fanta, Sprite, 7up, Limca, Mirinda, Mountain Dew, Coca Cola and Pepsi on dental enamel. Research analysis was also done to find out the relationship between the pH of the test soft drinks and their aggression towards enamel. These tests were carried out for one month at room temperature. It was found that non-cola drinks were two times more erosive than cola drinks. There was no co-relation between the pH of the test beverages and their enamel erosive capacity. Many factors are concerned with the erosive capacity of the soft drinks including type of acids, their calcium chelating properties, exposure time and temperature.*

Keywords : *Enamel, dental erosion, soft drinks, pH.*

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Introduction :

Soft drinks are the non-alcoholic artificially carbonated drinks which are consumed by a high percentage of people. The consumption of soft drinks by children, teenagers and adults has increased drastically in the last few decades. The greatest increase in consumption has been seen among children and adolescents. Nearly 40% of preschool children drink more than quarter of a litre of soft drinks per day (Harnack et al 1999). Majority of people consume them for their tangy flavour while some others consider them to provide a feeling of lightness. But soft drinks, which tend to be carbonated, have a low pH and mainly contain

filtered water, artificial additives and refined sugar, may subject dental enamel to erode from our teeth.

Besides the high sugar content of soft drinks, there is the presence of one or more food acids – phosphoric acid and citric acid are the harmful ones whereas carbonic acid formed by dissolution of carbon dioxide in water is responsible for tangy taste of soft drinks. Citric acid is the predominant acid in non-cola drinks. On the other hand, cola drinks contain phosphoric acid. This phosphoric acid is also responsible for staining or yellowing of the teeth. So, drinking any type of soft drink poses risk to the health of our teeth.

Dental erosion is irreversible, usually painless, loss of dental hard tissue that occurs due to a chemical process, such as dissolution, without the involvement of micro-organisms (Imfeld 1996).

Saliva in our mouth acts as a natural buffer to acids when introduced at a moderate rate. The pH of saliva lies within the range of 5.5 - 6.5; pH of 5.5 generally is accepted as the threshold level for the development of dental caries (Anderson et al 2001). The calcium in saliva works to mineralise teeth after exposure to small amounts of eroding acid, but with increased consumption of soft drinks, it is not enough. The frequency of soft drink consumption is an important factor in dental erosion (Dale 2002).

It is generally agreed that caries result from the action of bacteria on the teeth, the most common of which is *Streptococcus mutans*. These bacteria inhabit the plaque and depend to a great extent on carbohydrates for their food. When carbohydrates are available, their metabolic systems are strongly activated and they multiply. This metabolic reaction produces lactic acid as a waste product. The acid, in turn, dissolves the calcium in enamel of tooth (Guyton and Hall 2005). Coupled with the acid produced from bacteria, soft drink is a double threat to tooth enamel.

The aim of undertaking this topic was to find out which soft drink has the most erosive effect on dental enamel and the relationship between the erosive capacity and pH of the soft drinks.

Materials and Methods :

27 sterilized teeth were collected from Dr. B.R. Ambedkar Institute of Dental Sciences and Hospital, located at New Bailey Road, Patna. The test teeth were sound and caries-free human incisors (7), canines (10), premolars (4) and molars (6) extracted for orthodontic or periodontal reasons. These teeth especially belonged to teenagers between the age group of 14-18 years, who were occasional users of soft drinks. Eight soft drinks were selected. They were Fanta, Sprite, 7up, Limca, Mirinda, Mountain Dew, Coca Cola and Pepsi.

Each specimen tooth was weighed on an electronic balance and each tooth crown's diameter was measured using slide calipers. Besides these, pH of different test soft drinks was also measured using electronic pH meter. All studies were performed at room temperature.

The test beverages and test specimens were placed in glass test tubes with 5ml of the test beverage. 3 sets for each soft drink were taken. Besides test beverages, drinking water was also taken for comparative study. The specimens were allowed to soak in the test beverage for 60 minutes each, daily. They were allowed to dry for 23 hours and then again dipped in fresh test beverages. The weighing was done after 3 days interval. Average percentage weight-loss and weight-loss per unit area of each set of enamel specimens were calculated. The area of individual teeth was calculated considering molars, premolars and canines as cylinders by using the formula: $\pi r^2 + 2\pi rh$ i.e. area of upper surface + area of the sides of the cylinder, taking the half of the crown's diameter as its radius and height of the tooth above

(excluding its root length) the likely gum-level while surface area of the incisors was calculated considering them as typical trapeziums by using the formula: 2×h(a+b) i.e. area of outer surface + area of inner surface of trapezium, excluding the root length of incisors, where h is the height of incisors excluding the part below the gum-level, while a is the base-length of the right triangle and b is the base-length of the rectangle, that are taken into consideration while formulation in a trapezium.

Results and Discussion :

The result showed that water has minimal enamel dissolution capacity whereas all other test beverages exhibited a progressive attack on dental enamel. There was a progressive decrease in the weight of teeth. The average percentage of gross weight-loss and weight- loss per unit area of tooth are shown in Table 2. The average percentage weight-loss for Limca is highest i.e., 22.380% whereas lowest for Coca Cola i.e., 6.286%. Accordingly, the weight-loss per unit area for Limca is 0.131 mg/cm^2 and that for Coca Cola is 0.022 mg/cm^2. Water caused an average percentage weight loss of 1.57% and weight loss per unit area of 0.008 mg/cm^2. The research analysis found that non-cola drinks were more erosive than cola drinks. The enamel dissolution capacity of non-cola drinks was approximately two times greater than cola drinks.

Weight-loss of tooth was taken to be an indicator of the dissolution of its enamel, tooth's outermost covering. It was observed that cola drinks dissolved enamel about three times more than water whereas non-cola drinks dissolved enamel much more times than water. It was also observed that soft drinks that contained phosphoric acid, stained the exposed part of the immersed tooth that remains above the gum-level as well as the part which remains below the gum level, being less erosive than non-cola drinks which causes localised erosion of enamel i.e. just on the exposed part of tooth, leading to cavities. By pH measurement, it was found that there is no co-relation between enamel dissolution and pH of the test beverages. The pH of test beverages is shown in Table 1. The pH of Limca was the highest i.e., 4.00 whereas the pH of Coca Cola was the lowest i.e., 2.525. So, Coca Cola is the most acidic whereas Limca is the least acidic of all the test beverages.

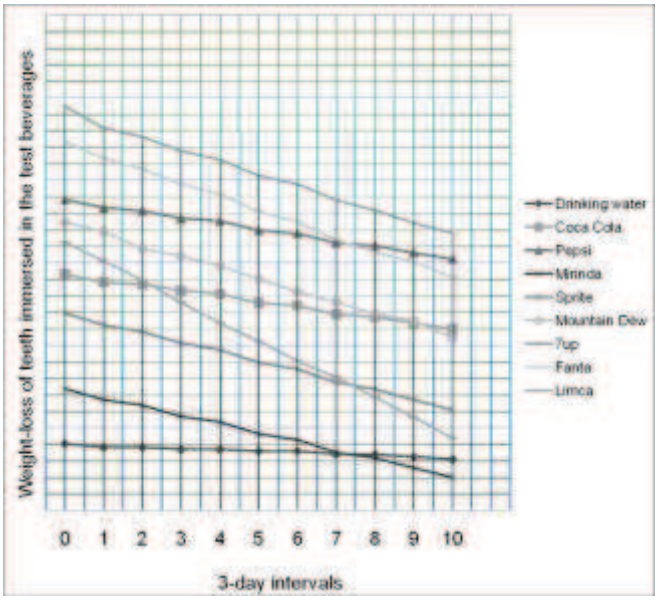
Table 1. Table showing the characteristics of test beverages

S. No.	Name	Sugar content (mg/100ml)	pH of test beverages	Acids present
1.	Mountain Dew	10.6	3.229	Citric acid
2.	Fanta	13.0	3.54	Citric acid
3.	Limca	11.0	4.00	Citric acid
4.	Mirinda	13.0	3.491	Citric acid
5.	7up	11.2	3.202	Citric acid
6.	Sprite	12.0	3.298	Citric acid
7.	Pepsi	10.0	2.530	Phosphoric acid
8.	Coca Cola	11.0	2.525	Phosphoric acid
9.	Drinking water	0.0	7.670	–

Table 2. Table showing average percentage of gross weight-loss, surface area of the tooth immersed in respective test beverages and weight-loss per unit area of tooth caused by test beverages

S. No.	Name of the test beverages	Average percentage of gross weight-loss	Surface area of tooth immersed (cm^2)	Weight-loss per unit area (mg/cm^2)
1.	Mountain Dew	12.857	0.614	0.0440
2.	Fanta	15.476	0.534	0.0608
3.	Limca	22.380	0.358	0.1310
4.	Mirinda	10.000	0.823	0.0255
5.	7up	13.809	0.596	0.0486
6.	Sprite	10.952	0.842	0.0273
7.	Pepsi	6.666	0.616	0.0227
8.	Coca Cola	6.286	0.600	0.0220
9.	Drinking water	1.571	0.412	0.0080

Fig 1. Showing gradual decrease in the weight of teeth immersed in respective test beverages and comparing them with drinking water



This pilot study exposed caries-free dental enamel to the test beverages over a period of one hour daily for one month. A similar study on the dissolution of dental enamel in soft drinks has been done by Fraunhofer and Rogers (2004) in which they exposed caries-free dental enamel to a variety of popular beverages continuously over a period of 14 days (336 hours). They concluded that tap water, root beer, brewed black tea and black coffee all showed minimal enamel dissolution whereas the carbonated soft drinks exhibited a progressive attack on dental enamel, with a linear or straight line relationship between enamel dissolution and exposure time over the test period.

Another study was done by Sarah (2006) on the dental effects of soft drinks and other beverages. Its objective was to find out which beverage had the most erosive effect on dental enamel. She used soft drinks as well as energy drinks for her study. She immersed the teeth in the selected beverages for a period of 7 days. The teeth were weighed at specific intervals throughout the immersion period with the beverages being changed daily. Her study concluded that enamel dissolution occured in all of the tested beverages, with far greater attack occurring in flavored and energy drinks than water and cola drinks.

In the present study, it was found that there was a gradual decrease in the weight of teeth immersed in the test beverages, which is very clear from the graph (Fig 1). However, there was a minimal dissolution of enamel of teeth immersed in water. A more interesting observation was the marked disparity in enamel attack by cola-based drinks as compared to non-cola drinks.

There is no co-relation between enamel dissolution capacity of the soft drinks and their pH. This suggests that enamel dissolution results from factors other than just beverage pH, more likely the additives within non-cola beverages that are necessary for achieving the desired palatability. Besides this, there are also some other important factors concerning the erosive quality of beverages that include the type of acids, their calcium chelating properties, exposure time and temperature. The enamel dissolution capacity of soft drinks is regardless of their sugar contents (Table 1).

Conclusion :

The study concluded that carbonated soft drinks may cause significant long-term enamel dissolution. The data clearly suggested that non-cola beverages are far more aggressive than cola drinks. Non-cola drinks were two times more erosive than cola drinks. It was also concluded that non-cola drinks are nine times more erosive than water whereas cola drinks are three times more erosive than water. Among non-cola drinks, Limca was the most erosive whereas Mirinda was the least erosive drink.

The data also suggested that enamel aggressivity is determined by beverage composition rather than by pH of beverages. It showed that Coca-Cola is the most acidic having a pH of 2.525, whereas Limca is the least acidic among all test soft drinks having a pH of 4.00 but the enamel dissolution capacity of Limca was about four times greater than that of Coca Cola.

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