

## Carbonated drinks and neutralizing saliva: dental erosion

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Received December 2003

### Summary

This article describes the effect of saliva (pH 7.6) on the pH of cola, bacardi-cola as well as on carbonated water. To investigate the effect of saliva on the pH of these drinks, both in vitro and in situ experiments are conducted. When in vitro - in a test tube - various amounts of either cola or bacardi-cola are added to 2.0 mL saliva a large drop in pH towards 4.0 was found, whereas carbonated water showed a moderate drop in pH just below 6.0. When drinking cola, bacardi-cola or carbonated water extra saliva production in the mouth starts. In situ keeping 5.0 mL of these carbonated drinks for 15 seconds in the mouth resulted in a larger pH increase of cola compared to the corresponding pH increase of bacardi-cola and carbonated water. Probably bacardi-cola (cola with alcohol) less stimulates the extra saliva secretion compared to cola and therefore results in a high acidic exposure of teeth. An exposure that creates erosion of the teeth.

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Preventive dentistry; Nutrition; Dental erosion

### Introduction

Carbonated drinks are known to have a low pH (pH < 4, see Table 1) with an erosive effect on enamel (Fig. 1). A tooth consists of an outer layer of enamel and an inner layer of tooth bone (dentine). Enamel mainly is hydroxyapatite -  $\text{Ca}_5(\text{PO}_4)_3\text{OH}$ . Acidic drinks can react with the hydroxy-group of the hydroxyapatite. Enamel decomposition takes place when the pH is below 5.5 [2]. Saliva produced in the salivary glands neutralizes acids and prevents this decomposition.



Fig. 1: Effect of bacardi-cola on enamel. ©

The question that rises is to what extent does saliva neutralize carbonated drinks? Normally saliva is produced to keep your mouth wet. When you eat or drink something, extra saliva production out of the parotid or glandula parotis (Fig. 2) starts.

Drink	pH	Drink	pH
Water	7.0	Sport drink	3.4
Tea	7.1	Orange juice	3.2
Fruit tea	< 6	Fanta orange	3.1
Milk	6.8	Apple juice	2.8
Buttermilk	4.4	7-Up	2.8
Beer	4.3	Bitter Lemon	2.7
Yoghurt	3.8	Cola light	3.3
Carbonated water	5.0	Bacardi-cola	2.9
Wine	3.4	Cola	3.1

Table 1: pH values for various drinks

This so-called 'chew stimulated' saliva has a higher buffer capacity than ordinary saliva. From this we expect that the pH of carbonated drinks will increase and will result in a less destructive effect on the enamel of teeth.

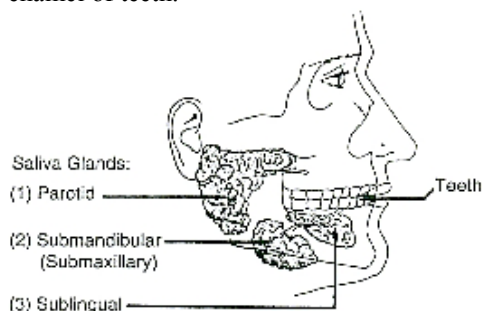


Fig. 2: Salivary Glands [3]

## Experimental procedure

### In vitro

To use a comparable composition of saliva for the test tube experiment ‘chew stimulated’ parotis saliva is obtained from stimulated saliva production by paraffin (candle). Therefore the backside of a candle is kept in the mouth and saliva which emerges is spat from the mouth in a beaker. The pH of this ‘chew stimulated’ saliva is measured with a pH-measuring instrument. Then 2.0 mL of each carbonated drink is added to separate beakers with each 2.0 mL of saliva. After this the pH value of the three mixtures is measured again. Then 2.0 mL of each carbonated drink is added to each mixture after which the pH is again measured. Finally 6.0 mL of each drink is added to the three mixtures and again the pH is measured. Each experiment is repeated several times.

### In situ

For the in-situ experiment 5.0 mL (equals a small swallow) of each carbonated drink - one by one - is kept in a mouth for 15 seconds. After this the swallow is spat from the mouth into a small beaker and the pH value is measured. In between the swallows the mouth is rinsed with tap water. Each experiment is repeated several times.

## Results

### In vitro

The pH of ‘chew stimulated’ saliva is  $7.6 \pm 0.2$ . After adding 2.0 mL of all three carbonated drinks the pH of saliva decreased below 6.0. More cola or bacardi-cola drastically decreased the pH of saliva; first, close to pH 4.0 and finally even below pH 4.0 (see Table 2 and Fig. 3).

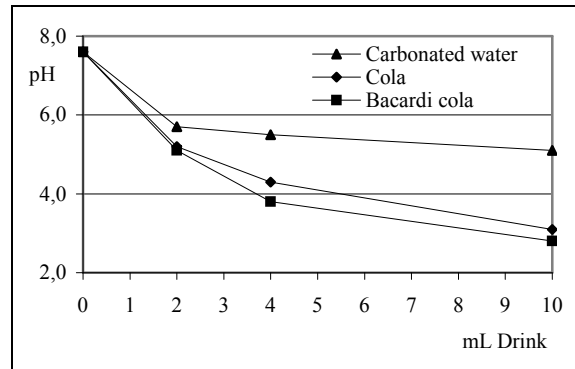
	pH After 2.0 mL drink is added	pH After another 2.0 mL drink is added	pH After another 6.0 mL drink is added
Carbonated water	$5.7 \pm 0.1$	$5.5 \pm 0.1$	$5.1 \pm 0.2$
Cola	$5.4 \pm 0.2$	$4.3 \pm 0.4$	$3.1 \pm 0.1$
Bacardi-cola	$5.1 \pm 0.2$	$3.8 \pm 0.2$	$2.8 \pm 0.3$

**Table 2:** pH values for various drinks

On the contrary, after adding more carbonated water (which itself has a pH of 5.0) the pH of saliva remained above 5.1.

### In situ

As can be seen in Table 3 and Fig. 4 the pH of cola changed from 3.1 to 4.3 after it had been in contact with saliva for 15 seconds, whereas the pH of bacardi-cola correspondingly changed from 2.9 to 3.4 and of carbonated water from 5.0 to 5.6.

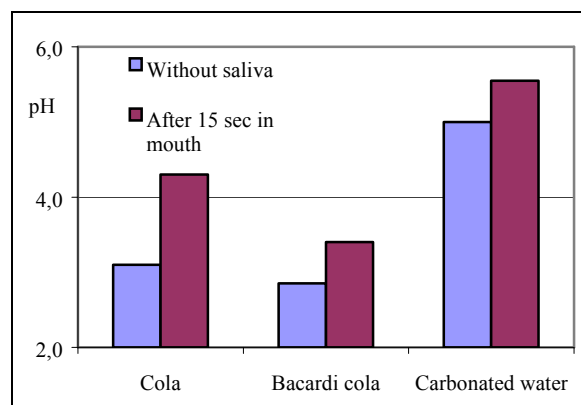


**Fig. 3:** In vitro pH after mL added drink

The difference ( $\Delta$ pH) is 1.2 for cola and is 0.6 for both bacardi-cola and carbonated water.

	pH before the experiment	pH after 15 seconds in situ	Difference $\Delta$ pH
Carbonated water	$5.0 \pm 0.2$	$5.6 \pm 0.1$	$0.6 \pm 0.2$
Cola	$3.1 \pm 0.1$	$4.3 \pm 0.2$	$1.2 \pm 0.1$
Bacardi-cola	$2.9 \pm 0.3$	$3.4 \pm 0.2$	$0.6 \pm 0.2$

**Table 3:** In situ pH of 5 mL drink in the mouth



**Fig. 4:** In situ pH of 5 mL drink in the mouth

## Conclusion

From the in vitro experiments it can be concluded that carbonated water is neutralized by saliva in such a way that the critical pH (5.5) for dental erosion is prevented. But for the two other drinks this is not the case.

The in situ experiments show that 5.0 mL (one swallow) of cola or bacardi-cola is neutralized by saliva resulting in a pH around 4.0. Therefore far below the critical pH for dental erosion. These acidic solutions will react with (erode) hydroxyapatite in the enamel. Another conclusion is that cola is neutralized by saliva more than bacardi-cola.

## Discussion

After drinking carbonated water the pH in the mouth is high enough (5.6) to have no harmful effect on teeth. This, however, is not the case for cola and bacardi-cola. These drinks create a pH in the mouth, which is below the critical level of 5.5 and therefore cause dental erosion. Furthermore, people drink them swallow-by-swallow and thus continually expose their teeth to an acidic environment.

However, there is a difference between cola and bacardi-cola in the in-situ experiment. In the mouth saliva neutralizes cola more than bacardi-cola. A difference that may be caused by a stronger saliva stimulating effect of cola compared to bacardi-cola.

An explanation to this could be that on the one hand the alcohol (5-7%) in bacardi-cola less stimulates saliva production in the mouth. On the other hand it could be that bacardi-cola, compared to cola, sticks better to teeth and thus allow bacteria to convert sugar ( $C_6H_{12}O_6$ ) into lactic acid ( $C_3H_6O_3$ ). Hence a lower pH in the mouth.

Explanations that raise questions like: What will be the effect of saliva on the pH of bacardi-cola, in which the 5-7% of alcohol is replaced by water? Will the use of artificial saliva give the same results? Or can artificial saliva be made with a higher or lower buffer capacity than real saliva?

To investigate the effect of carbonated drinks on teeth, chicken or bovine bones can serve as a model. Bovine bones resemble teeth the most, but react just like teeth at a very low rate with acids. Chicken bone does have a comparable but less dense structure of hydroxyapatite than the enamel of teeth and reacts with carbonated drinks at a higher rate.

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