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Evaluation of hydrogen ion modulation in human dental plaque following consumption of regular and diet soft drinks

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The high cariogenicity of all black cola drinks is recognized by all oral health care professionals. It has been proven that black cola drinks pose a threat to the integrity of tooth structure. Despite the presence or absence of artificial sweeteners in cola drinks, both regular and diet soft drinks still contain phosphoric and citric acid, which contributes to the total acidic challenge potential on enamel. Fourteen children (8 to 15 years of age) were recruited with DMFT +deft ≤3. Subjects were instructed to stop brushing 48 h prior to the appointment. Plaque samples collected and dissolved in the test beakers having 1 ml of double distilled water and pH was determined immediately inherent pH of the test drinks was measured. Five minutes after the consumption of each drink, the plaque sampling was done. The pH was recorded after 10, 20, 30, 40 and 60 min of the post consumption period. All the test drinks dropped the plaque pH below the critical pH indicating that the entire four carbonated beverage were capable of causing dissolution of enamel. That all carbonated beverages have virtually the same effect on acid production in plaque and thus are equally erosive.

Key words: Diet coke, regular coke, diet pepsi, regular pepsi, pH, saliva.

INTRODUCTION

Recent advertising material from companies which manufacture black cola soft drinks should be of concern to all oral health professionals. Some of the advertising material on the coca cola website makes interesting reading, to say the least. “MYTH: drinking coca cola will rot your teeth” (http://www.coca-cola.com.au/pemberton/Myths.html). Drinks like coca cola are swallowed quite quickly and saliva in the mouth quickly washes away the sugar and acid. The explanation portrayed by the beverage manufacturing companies in the mass media does not coincide with experience of the dental practitioners.

The high erosive potential of all black cola drinks is recognized by all oral health care professionals. Through

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Table 1. Distribution of sample and the carbohydrate content and endogenous pH of the test drinks.

Distribution of sample			Carbohydrate content (g)	Endogenous pH
Group	Number of children	Test drink and control		
I	14	Regular coke	39	2.48
II	14	Diet coke	0	3.22
III	14	Regular pepsi	41	2.46
IV	14	Diet pepsi	0	2.94
V	14	Sucrose 10% (control)	10	5.20

various experiments, it has been proven that black cola drinks pose a threat to the integrity of tooth structure by: phosphoric acid, citric acid present in the cola drink and the acid produced by the dental plaque microflora; the sugars in these drinks are metabolized by plaque microorganisms to generate organic acids that bring about demineralization leading to dental caries.

By comparison, phosphoric acid and citric acid, which can be found in practically every commercial soft drink on the market, can have similar acidogenic effects on the enamel. An acidic solution without sugars, like diet coke and diet pepsi, lowers dental plaque pH, because it confers protons (H+), while a neutral sucrose solution lowers plaque pH due to the acidogenic capacity of the plaque bacteria. Despite the presence or absence of artificial sweeteners in cola drinks, both regular and diet soft drinks still contain phosphoric and citric acid, which contributes to the total acidic challenge potential on enamel. To date, there has been minimal information that has discussed the pH effects on dental plaque comparing regular and diet soft drinks (Roos and Donly, 2002).

MATERIALS AND METHODS

Fourteen children in the age group of 8 to 15 years were recruited for the study with dmft +DMFT not more than 3. The subjects selected in this study had no filling on the labial/buccal and lingual surfaces of teeth, no gross malocclusion, especially overcrowding. Parental consent was taken before selecting the subjects for the study. Four commercially available carbonated beverages, two containing sugar and two without sugar were compared against 10% sucrose solution which served as control. An appointment was arranged for each consenting subject to return. Before the start of the investigation, each child was given a thorough oral prophylaxis and the child was advised not to brush for 48 h. The child was then called on the third day at a fixed time, to exclude the variation in plaque metabolism in the experiment. The child was advised not to take anything except plain water before coming to the clinic. Dental plaque samples were collected from different spots on buccal/labial and lingual surface of teeth (within a period of 30 to 60 s) and dissolved in the test beakers having 1 ml of double distilled de-ionized water and pH was determined immediately (within 90 s) to record resting plaque pH with the help of pH meter. Inherent pH of the beverages and the sucrose were measured (Table 1).

Each child was given the test drink to be consumed slowly over a period of 3 to 5 min. Five minutes after the consumption of drink, the plaque sampling was done in the same manner as described earlier.

Similarly, the pH was recorded after 10, 20, 30, 40 and 60 min of the post consumption period. After each experiment, each of the participating subjects was made to follow the normal oral hygiene regime for five days before the start of next experiment. The resting plaque of each child was taken whenever the next experiment was performed. Similar sequence of events of procedure was followed for each drink group and sucrose rinse. Finally, the obtained results were compiled and subjected to statistical analysis.

RESULTS

Figure 1 and Table 2 show the plaque H^+ ion modulation at specified time intervals during pre and post consumption of carbonated beverages and control.

Group I (Test drink-Regular coke): The maximum plaque pH drop occurred at 20 min (4.45±0.32). The plaque pH remained below the critical pH level up to 30 min (5.22±0.23) and it started gradually increasing after 40 min up to the level of 5.58±0.17 at 60 min

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Group II (Test drink-Diet coke): The maximum plaque pH drop occurred at 20 min (4.79±0.30) and it remained below critical pH till 30 min (5.31±0.21) and started gradually increasing upto 6.15±0.21 at 60 min.

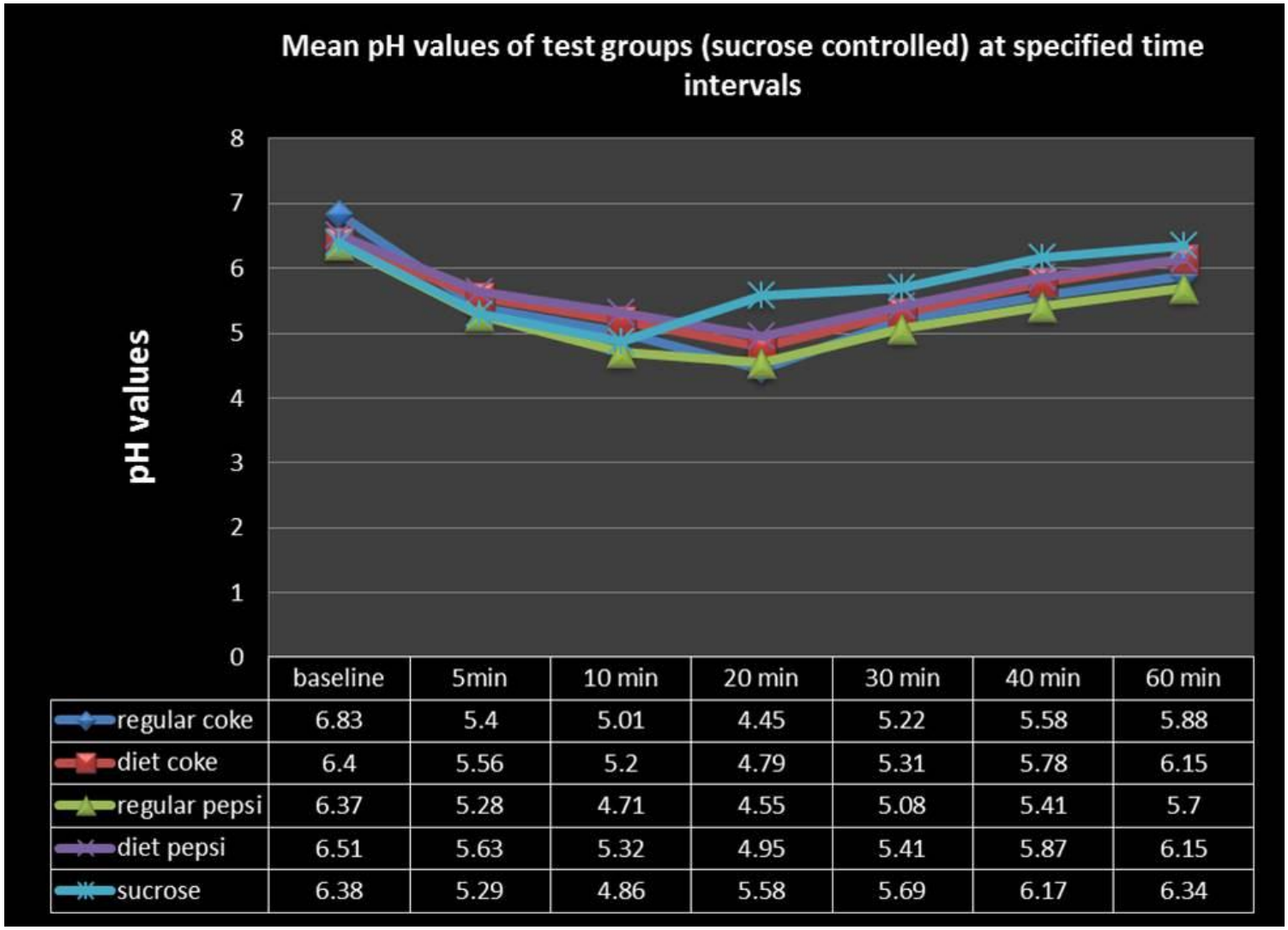
Group III (Test drink-Regular pepsi): The maximum fall in plaque pH was 4.71±0.24 at 10 min and thereafter, it gradually rose to 5.70±0.17 at 60 min.

Group IV (Test drink-Diet pepsi): The maximum plaque pH drop was recorded at 20 min interval which started rising after 30 min till 60 min when it approached near the resting plaque pH.

Group V (Control): The value dropped maximum at 10 min (4.86±0.05) and thereafter, it gradually rose to 6.34±0.11 at 60 min interval.

DISCUSSION

Dental caries development involves a series of events in a biofilm denominated dental plaque, where bacterial interactions with microorganisms or to dental surface,



	baseline	5min	10 min	20 min	30 min	40 min	60 min
regular coke	6.83	5.4	5.01	4.45	5.22	5.58	5.88
diet coke	6.4	5.56	5.2	4.79	5.31	5.78	6.15
regular pepsi	6.37	5.28	4.71	4.55	5.08	5.41	5.7
diet pepsi	6.51	5.63	5.32	4.95	5.41	5.87	6.15
sucrose	6.38	5.29	4.86	5.58	5.69	6.17	6.34

Figure 1. Mean pH values of test groups (sucrose controlled) at specified time intervals.

ecological changes driven by diet, physicochemical aspects inherent to the process and the composition and properties of dental plaque matrix are challenging to researchers (Cury et al., 2000; Zero, 1996). Many dental plaque bacteria can ferment carbohydrate

Table 2. Intracomparison of mean plaque pH of various test drinks/control at specified time intervals.

Group number	Name of the test group	Pre consumption plaque pH	Post drink consumption plaque ph recordings											
			5 min	Diff.	10 min	Diff.	20 min	Diff.	30 min	Diff.	40 min	Diff.	60 min	Diff.
		1	2	1&2	3	1&3	4	1&4	5	1&5	6	1&6	7	1&7
I	Regular coke	6.83±0.13	5.40±0.28	0.98±0.34	5.01±0.18	1.37±0.25	4.45±0.32	1.84±0.31	5.22±0.23	1.16±0.24	5.58±0.22	0.80±0.23	5.88±0.17	0.50±0.25
	t-value	-	-	12.234**	-	11.448**		19.308**	-	14.489**	-	10.685**	-	7.772**
II	Diet coke	6.40±0.25	5.56±0.27	0.88±0.36	5.20±0.23	1.20±0.36	4.79±0.30	1.61±0.43	5.31±0.16	1.10±0.36	5.78±0.21	0.67±0.28	6.15±0.21	0.38±0.24
	t-value	-	-	9.164**	-	12.428**	-	13.999**	-	10.665**	-	6.488**	-	3.485*
III	Regular pepsi	6.37±0.20	5.28±0.31	1.08±0.34	4.71±0.24	1.43±0.25	4.55±0.27	1.80±0.31	5.08±0.21	1.29±0.24	5.41±0.21	0.96±0.23	5.70±0.17	0.67±0.25
	t-value	-	-	11.814**	-	20.766**	-	21.690**	-	21.005**	-	15.430**	-	10.355**
IV	Diet pepsi	6.51±0.25	5.63±0.26	0.88±0.38	5.32±0.25	1.18±0.37	4.96±0.17	1.48±0.35	5.41±0.19	1.02±0.38	5.87±0.22	0.66±0.30	6.13±0.19	0.45±0.23
	t-value	-	-	8.632**	-	11.677**	-	16.615**	-	11.109**	-	6.305**	-	3.953**
V	10% sucrose solution	6.38±0.29	5.29±0.21	1.29±0.25	4.86±0.06	1.73±0.26	5.58±0.28	1.01±0.39	5.69±0.36	0.69±0.31	6.17±0.18	0.42±0.30	6.34±0.11	0.26±.22
	t-value	-	-	19.420**	-	24.247**	-	9.532**	-	8.246**	-	5.187**	-	3.644*

substrates, and a large number of organic acids (of varying potency for demineralization) result from this process. For this reason, it is logical to look at the plaque biomass and the net result of fermentation, rather than to focus narrowly on just one species or just one organic acid. An assessment of acid production from carbohydrate by dental plaque bacteria can be used to assess the cariogenicity of dental plaque from a particular site. As fermentation proceeds, the plaque pH decreases to approximately 4 within 5 min, and this state of lowered pH persists for up to several hours, depending on the presence of salivary protection factors (Walsh, 2015).

To control various biological parameters, such as microbial ecology of the oral cavity, rate of plaque formation, initial resting plaque pH, etc., the same subject was exposed to the four test drinks and control in order to study the H^+ ion modulations in plaque so that the post consumption plaque pH values could be directly compared and the biological error of the experiment could be reduced to a minimum. The time variable was also controlled as the time between plaque sample collection and pH determination was kept as short as possible (30 to 40 s) during different intervals in the various test groups and control. In order to avoid further fermentation after collection of plaque samples which could lead to a further fall in plaque pH, the pooled plaque samples were immediately immersed in cold double distilled water and pH was determined till constant readings on pH meter were received.

Carbonated beverages, in general, have been shown to possess an acidogenic potential due to the presence of carbonic acid formed by carbon dioxide in solution (Stephan, 1966). Since both coke and diet coke are carbonated, it could be deduced that the erosive potential caused by carbonic acid is the same with either drink.

Parameters to study erosive potential

Apart from H^+ ion modulation in plaque pH, various other methods have been suggested in recent years to determine the cariogenicity of the food consumed. In the present study, two parameters have been used to determine the cariogenicity of the test drinks: (i) inherent pH of the test drinks and control (Stephan, 1966, 1940; Hussein et al., 1996); (ii) plaque pH (comparison between the baseline pH and the post consumption plaque pH at 5, 10, 20, 30, 40 and 60 min time intervals) (Marthaler, 2004).

In the present study, the inherent pH of all the four test drinks was low. Least endogenous pH was that of regular pepsi (2.46) followed by regular coke (2.48), diet pepsi (2.94) and lastly

diet coke (3.22).

All the four test drinks by the virtue of their low endogenous pH were able to drop the plaque pH below the critical pH indicating that all the four carbonated beverage were capable of causing dissolution of enamel. Regular coke with the least endogenous pH thereby being the most acidic was able to bring the maximum initial rapid pH drop and the maximum pH drop at 20 min. On the other hand, regular pepsi which had endogenous pH slightly more than regular coke was able to bring the most sustained pH drop in plaque. Thus, the low inherent pH of the beverages can be an important factor responsible for their increased potential erosive potential.

Conclusion

In general, the results of the present experiment pointed out toward two main determinants: (i) extent of pH fall; (ii) duration of pH fall, which should be considered as a measure of cariogenicity of foods. According to these parameters, regular pepsi was found to be most erosive followed by regular coke, diet coke and diet pepsi.

The next most important conclusion which could be drawn from this experiment was that all the carbonated beverages have virtually the same effect on acid production in plaque and thus, carbonated beverages with no added sugars are equally erosive.

All the carbonated beverages used in the present study were acidic in nature and reduced plaque pH below critical pH especially in the caries active group. Hence, it becomes mandatory for us as preventive dentists, to provide appropriate diet counseling which is tailored for a particular individual to maximize compliance.

Conflict of Interests

The authors have not declared any conflict of interests.

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