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Effect Of Oral Rehydration Solution On Salivary And Dental Plaque pH: An In-Vivo Study

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Abstract:
Aim: *To assess the salivary and plaque pH after consumption of the oral rehydration solution by different methods.*
Methods: *Most widely used and most frequently prescribed brand of ORS was taken as the test drink in the study. Thirty six healthy subjects aged 20-26 years who satisfied the inclusion criteria were selected and were divided into three groups (Group A - rinsing, Group B - glass, Group C - straw) by lottery method. Saliva and dental plaque were collected after consuming the drink in one, five, ten, twenty, and thirty minute intervals. The salivary and plaque pH was assessed by digital pH meter. ANOVA and post hoc Tukey's test were used for statistical analysis using SPSS 20.0 version.*
Results: *Highest mean pH drop of plaque (4.74) and saliva (4.89) was recorded in group A at all the time intervals. There was a significant difference in plaque pH (P<0.05) between all the three groups at all the time intervals and significant difference in salivary pH (P<0.05) was observed in the first 20 minutes, whereas no significant difference was seen in the 30 minute interval (P>0.05) when ANOVA was used. There was a statistical significant difference observed between Group A and Group C at all the time intervals in the plaque pH and a statistical difference at all the time intervals expect at the 30 min interval was observed between Group A and Group C in the salivary pH when Post-Hoc Tukey's test was done for one to one group comparison.* ***CONCLUSION:*** *Highest drop in the pH was observed when ORS was consumed after rinsing, whereas the least drop was observed when consumed with the help of a straw.*
Key Words: *Oral rehydration solution, plaque pH, salivary pH*

I. Introduction

Enamel is the hardest and highly mineralised tissue in the human body and yet it can be destroyed by various factors, thus making dental caries one of the most unusual diseases. Once established it is perpetual and does not confer any immunity what so ever. It involves all population groups in the world [1]. Keys and Jordan (1963) formulated that caries development requires a triad of the indispensable factors, namely dietary carbohydrate, dental plaque bacteria, and caries susceptible teeth. The link between plaque acidity (pH) per se and cariogenicity depends on the extent of the drop in plaque pH, influenced particularly by lactic acid and its duration [2]. The classical studies such as The Vipeholm Study [3], Turuku Study [4], Hope wood House Study [5] etc. provide evidence supporting the role of sugar in the aetiology of dental caries. These clinical evidences implicate that, frequent consumption of sugar in the aetiology of caries is much stronger than the evidence supporting the widely held belief that caries is an infectious disease caused by mutans streptococci [6]. Thereby it is well established that fermentable carbohydrates and microorganisms in the plaque play a significant role in the pathogenesis of dental caries.

The sugar most commonly associated with dental caries is sucrose and has been termed as the arch criminal of dental caries [7]. Oral Rehydration Solution (ORS) is one product containing glucose, a fermentable sugar as one of its main components. It was originally developed in the early 1970s to correct the substantial dehydration that occurs as a result of severe diarrhoea, especially acute infectious diarrhoea. In its simplest and original form, ORS is an iso-osmolar, glucose-electrolyte solution with added bases that was designed to correct dehydration and metabolic acidosis [8]. Alternative formulations continued to be investigated in an attempt to develop an ORS formulation that would have other clinical benefits. These efforts led, in 2004, WHO to recommend low osmolarity ORS (with a total osmolarity of 245 mmol/l and reduced levels of glucose and sodium) [9]. As the ORS product contains carbohydrate glucose it is expected to lower the pH in the oral cavity and thereby be cariogenic.

Several researches have been conducted to measure plaque and salivary pH changes following the differences in drinking methods such as holding, short-sipping, long-sipping, gulping, nipping and sucking to study the intraoral pH response [10]. Another study reported that the manner in which the dietary acids are introduced into the mouth (gulping, rinsing, and use of straw) will affect which teeth are contacted by erosive challenge and possibly the

clearance pattern [11]. Another study reported that drinking the product either from a glass or a straw resulted in a smaller pH drop than a mouth rinse [12].

Despite the deleterious effects of sugars on dental health, and the incontrovertible role of sugars as the major factor responsible for the present upsurge in dental caries prevalence in the developing countries the use of ORS can't be restricted based on this drawback alone. Therefore, this study was conducted to establish a possible solution for limiting the occurrence of dental caries by ORS. Based on the fact that the method of intake affects dentition, this study aims to assess the salivary and plaque pH after consumption of ORS by different methods, with the objective to estimate the pH of the ORS and to record the changes in the plaque and salivary pH after consuming ORS at different time intervals with a plastic glass, straw and drinking after rinsing.

II. Materials & Methods

A single center, randomized experimental study was conducted in the department of Public Health Dentistry, Narayana Dental College and Hospital, Nellore, Andhra Pradesh in the month of August, 2014 among students of Narayana Dental College who were willing to participate in the study, who gave a written consent and who satisfied the inclusion criteria. Healthy subjects who were aged 18 years and above, with full complement of permanent dentition (except the third molars), who had a DMFT score of less than or equal to three and currently not under any medication were included in the study. Subjects who had known or suspected intolerance/hypersensitivity to study materials closely related to compounds/ingredients used in the study were excluded.

The ethical approval for the study was obtained from the Institutional ethical committee (IEC) of Narayana Dental College and Hospital, Nellore. The sample size was calculated based on the least detectable difference obtained in the previous study [18] i.e., 0.1, with a standard deviation of ±0.4, allowable mean error of 0.1 and at a confidence interval of 95% . The sample size was estimated to be 12. As three groups were involved in the study, 12 subjects were allotted to each group, i.e. a total of 36 subjects participated in the study.

1.1. Sampling Methodology:

A total of thirty six subjects aged between 20 to 26 years who satisfied the inclusion criteria were randomly allocated to three groups, i.e., 12 each for Group A (Rinsing), Group B (Glass) and Group C (Straw) by lottery method.

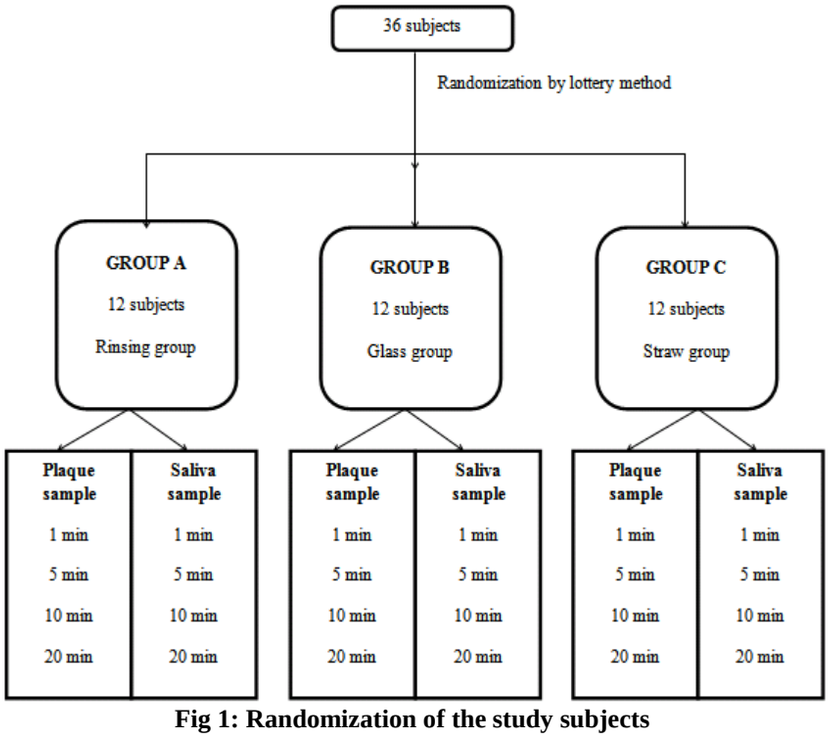

Fig 1: Randomization of the study subjects

1.2. Selection Of The Test Solution:

A short survey was carried out among general practitioners and pharmacists to select the test solution (ORS), which was available under different trade names, manufactured by various companies. The most widely used and most frequently prescribed brand was finally selected as the test solution i.e.,"Electral" which is manufactured based on WHO formula (Table 1), manufactured by FDC limited (Regd. Office: B-8, M.I.D.C., Waluj, Dist. Aurangabad 431 136). Each sachet (4.40 g) of Electral was dissolved in 200 ml of drinking water for consumption according to the manufacturer's instructions (Table 2). The selected ORS was subjected to pH assessment after it was dissolved in

drinking water. The pH of the test solution (ORS) was determined using a digital pH meter prior to the beginning of the study.

1.3. Study Procedure:

The subjects were instructed to refrain from any sort of oral hygiene practice procedure for 24 hours before the study and were asked to abstain from any food or drink except water eight hours prior to conducting the study
The subjects of group A were given the ORS and were instructed to drink the solution after rinsing in the mouth for one minute. The group B subjects were instructed to drink the solution from a plastic glass directly. The subjects in group C were given a plastic straw and were asked to drink ORS with the help of the straw.

1.4. Collection Of Saliva:

Subjects were asked to sit comfortably in a chair for sample collection. Saliva sample was collected before the plaque sample was collected to avoid contamination of the plaque sample with saliva. Stimulated saliva was collected by spitting method, i.e., the subjects were instructed to collect the saliva in the oral cavity and then void into a receptacle (container) [13]. The subjects were given a plastic tumbler and asked to spit into the tumbler, a minimum of 10 ml of saliva was collected at each time. Samples of saliva were collected from all the subjects at 1 minute, 5 minutes, 10 minutes, 20 minutes, and 30 minutes after consumption of ORS

1.5. Collection Of Plaque:

Plaque sample was collected using the method of Fosdick et al. modified by Frostell and Rugg-Gunn et al [14]. The subjects were asked to sit in a chair comfortably. They were asked to swallow immediately before plaque collection to avoid contamination with saliva, and during sample collection care was taken to avoid contamination with blood or saliva. The plaque sample was collected using a blunt sterile stainless steel probe by the examiner from the buccal surfaces of the maxillary molars (16, 26), the labial surface of the maxillary incisor (11), the lingual surfaces of the mandibular molars (36, 46) and the lingual surface of the mandibular incisor (31) at 1 minute, 5 minutes, 10 minutes, 20 minutes, and 30 minutes after consumption of ORS. The collection time for each sample was standardised (30 seconds).

1.6. Assessment Of The Plaque & Salivary Ph:

The pH of saliva and plaque was measured using the digital pH meter [15]. The digital pH meter used in this study was, Digital pH meter, Ri, model: 152-R, A product of an ISO 9001-2000 certified company, with a range of 0-14 pH, declared as highly stable. Calibration of the pH meter was carried out prior to the study using standard solutions of pH 7.0 and 4.0 according to the manufacturer's instructions. In between each reading the glass bulb of the pH meter was cleaned with a stream of distilled water and placed in a standard solution of pH 7.0. This ensured stable readings and a constant check on drift. For estimating the salivary pH the saliva sample was collected in a sterile plastic tumbler till the entire bulb was dipped in the saliva. The plaque sample was mixed with 10 ml of distilled water till the entire bulb was dipped. The pH was read after allowing the reading to stabilize for 30 seconds. Only 4 subjects were studied per day between 7:00 am and 9:00 am.

1.7. Statistical Analysis:

The data were analyzed using version 20 of SPSS. The mean and standard deviation were calculated. ANOVA was used to compare the mean plaque and salivary pH levels in between the three groups at different time intervals and the Post-Hoc Tukey's test was used for the additional exploration of the differences among means to provide information on which means are significantly different from each other. A Stephan's curve was also plotted.

III. Results

A total of 36 subjects participated in the study. The mean age of the participants was 22±2.02 with an age range of 20 – 26 years. 14 participants were males and 22 participants were females. The subjects were divided randomly into three groups, A (Rinsing group), B (Glass) and C (Straw) by the lottery method equally. Among the various brands of ORS available in the market, the most widely used and most frequently prescribed brand of ORS was taken as the test drink in this study. The pH of this test solution was estimated to be 4.23.

1.8. The mean plaque pH of the study participants in three different groups after consumption of ORS at different time intervals

The mean plaque pH drop was highest during the five minute interval in all the three groups, (4.74 for Group A, 5.50 for Group B and 6.82 for Group C) which gradually recovered to neutral over time and was nearly similar in all the three groups after 30 minutes. Among the three groups lowest mean plaque pH was seen in Group A (Rinsing group) (4.74) during the 5 minute interval. (Table 3)

1.9. The mean salivary pH of the study participants in three different groups after consumption of ORS at different time intervals

The mean salivary pH drop was highest during the first minute in all the three groups, (4.89 for Group A, 5.44 for Group B and 6.78 for Group C) which gradually recovered to neutral pH after 30 min. Among the three groups lowest mean salivary pH was seen in Group A (4.89) during the first minute. (Table 4)

1.10. Comparison of mean plaque pH levels between the three groups at different time intervals.

The highest plaque pH drop was seen in Group A (4.74), followed by Group B (5.50). The least plaque pH drop was seen in Group C (6.82). There is a drastic drop in plaque pH at 1 min after consuming ORS in all the three groups, the drop increased for 5 minutes in Group A and Group B, but the pH drop of Group C never reached the critical pH. In-between group comparison at different time intervals using ANOVA showed a significant difference between all the three groups ($P<0.05$) (Table 5). Following ANOVA a post Hoc assessment was done for one to one group comparison using Post-Hoc Tukey's test. There was a statistical significant difference between Group A and Group C at all the time intervals, clearly proving that the method used in Group C was far better than the method used in Group A for consuming ORS (Table 7).

1.11. Comparison of mean salivary pH levels between the three groups at different time intervals.

The salivary pH drop was highest in Group A (4.89), followed by Group B (5.44), in-turn followed by Group C (6.78). A drastic drop in the salivary pH was observed during the first minute in all the three groups. The pH continued to gradually increase over a period of 30 minutes. The salivary pH never reached the critical value in Group C. A significant difference ($P<0.05$) was observed in the first 20 minutes, no significant difference was seen in the 30 minute interval ($P>0.05$) when ANOVA was applied for in-between group comparison (Table 6). Post-Hoc Tukey's test done after ANOVA for one on one group comparison showed a statistical difference at all the time intervals expect at the 30 min interval among Group A and Group C (Table 7).

1.12. A plaque pH curve (fig 2) and a salivary pH curve (fig 3) were plotted for ORS consumed by all three different methods.

The plaque pH curve shows that there was a decrease in the plaque pH for Group A and Group B during the first 5 min followed by a gradual increase. The drop was higher in Group A when compared to Group B. The pH values at all the time intervals in Group C remained relatively stable with no major changes (fig 2). The salivary pH curve, following the initial drop at the 1 min interval shows a gradual increase in the salivary pH in Group A and Group B. Group C showed a slight increase in the 5 min interval only, later it remained stable. Even at the end of 30 minutes the salivary pH of Group A was still little lower than the other two groups (fig 3). This indicates that Group C didn't show much variation in plaque and salivary pH values over a time period of 30 minutes even after consumption of ORS.

IV. Discussion

This study was done to determine the effect of ORS on plaque and salivary pH after consuming it by three different methods; drinking after rinsing (Group A), directly from a glass (Group B) and with the help of a straw (Group C). Thirty six subjects who participated in this study were randomly allocated to one of the three groups by lottery method equally. The plaque and salivary pH were measured at different time intervals after the consumption of ORS by the participants by three different methods.

There are many factors that contribute to the initiation of caries by various drinks; they are its acidogenicity, sugar content, how often it is consumed and most importantly how it is consumed. Although there is no single test which can unambiguously determine the cariogenicity of any food or drink, in vivo studies on their ability to depress plaque pH may give insight into their potential to cause demineralization. Measurement of plaque or salivary acidity, principally as a change in the plaque or salivary pH over a period of time, forms an important group of tests for assessing potential cariogenicity of foods and drinks [16].

It is a well-established fact that sugar most commonly sucrose is the arch criminal of dental caries and many studies have been done to prove its effects on the teeth. Many studies also have been done to establish the cariogenic potential of various carbonated drinks and fruit juices; these have increased the awareness of the population about oral health [17], but such knowledge and awareness regarding the adverse effect of ORS on the oral hard tissue is quite low. It will be absurd to avoid ORS when necessary based on the only fact that it is cariogenic as it has been proved in many studies throughout the world as the cornerstone of therapy for dehydration [8].

In this study three different methods of consumption of ORS were used and all the three methods led to changes in the plaque and salivary pH with a gradual recovery over 30 minutes. This study showed that drinking with straw leads to a lower plaque and salivary pH drop when compared to drinking from a glass and drinking after rinsing in the mouth. The resting plaque and salivary pH usually range from 6 - 7. When any drink of a low pH is consumed, it causes a fall in this resting pH. The length of the time for which this low pH remains at its minimum is important, since if it reaches the so called critical pH (5.5), it initiates the dissolution of the enamel. The test solution ORS used in the present study was found to be acidic with a pH of 4.23. This ORS was consumed in three different ways to

establish which method causes least changes in the salivary and plaque pH, so that it does not harm the oral hard tissue.

The observed beneficial effect of consuming a drink with the use of a straw is probably a reflection of the period of contact between drink and plaque and saliva. 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 the mouth, it would be swallowed quickly and the contact between the plaque and salivary organisms and ORS is reduced. This finding is in concurrence with some study reports [11,18]. One study confirmed that oral rehydration therapy products have a high cariogenic potential [19], they conducted the study to investigate oral rehydration therapy (ORT) products and their effect on plaque pH under normal and dry mouth conditions, they said that dry mouth condition, obtained by injection of methylscopolamine nitrate in the labial sulcus, resulted in an overall more pronounced fall in pH as well as a delay in the pH recovery compared with normal salivary conditions and that ORT products are easily fermented in the oral cavity, resulting in low pH levels, thereby increasing the caries risk. Microbial aetiology of dental caries is the dynamic relationship among the dental plaque microbiota, dietary carbohydrates, saliva and pH lowering, and the cariogenic potential of the dental plaque and caries occur preferentially on the dentition sites characterized by high exposure to carbohydrate and diminished salivary effect [7]. It has been proved in some other studies that erosion depth increases with increasing erosion time and decreasing pH of the food substance or drink [20] and that differences in the drinking habits may lead to differences in the pattern of erosion [21].

The findings in the present study suggest that the most harmful method of consuming ORS is drinking after rinsing; the best method of consuming ORS is by drinking it with the help of a straw. The changes in pH of dental plaque and saliva crossed the critical pH when consumed after rinsing it in the mouth; this confirms the fact that the change in the pH of dental plaque and saliva is affected by the time of contact of the ORS with the teeth. In the same way as drinking with a straw has minimum contact time with the teeth there was no significant change in the plaque and salivary pH. The more pronounced pH fall was observed when the drink came in contact with all the teeth surfaces and was retained for a longer duration, causing increased acid production in the dental plaque pH and saliva [18].It would be naïve to stop the usage of ORS. In the light of the present data, it would appear that the use of straw could limit its harmful effects on dentition.

V. Conclusion

The study clearly demonstrate the acidogenic potential of ORS. There was a significant drop in the salivary and plaque pH after consumption of ORS. The highest drop in the salivary and plaque pH was observed when ORS was consumed after rinsing where as the least drop was observed when ORS was consumed with the help of a straw.

VI. Recommendations

Given the concerns of the dental profession and the known possible detrimental effects of ORS, emphasize should be placed on the method of consuming ORS. Modification of certain habits such as avoiding swishing the drink in the mouth before swallowing and the use of straw is useful to reduce the contact and contact time of the ORS with the teeth surfaces.

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Table 1: Composition of one sachet (4.4 g) of Electral

Sodium Chloride	0.52 g
Potassium Chloride	0.30 g
Sodium Citrate	0.58 g
Dextrose Anhydrous	2.70 g

Table 2: Composition of 4.4 g of Electral in 200 ml of water

Electrolytes	**mOsmol/Litre**
Sodium	75
Potassium	20
Chloride	65
Citrate	10
Dextrose	75
Total Osmolarity	245

TABLE 3: The mean plaque pH of the study participants in three different groups after consumption of ORS at different time intervals

GROUP	1 min	5 min	10 min	20 min	30 min
	MEAN±SD	MEAN±SD	MEAN±SD	MEAN±SD	MEAN±SD
GROUP A	5.25±0.42	4.74±0.37	5.50±0.39	6.19±0.57	6.58±0.44
GROUP B	5.61±0.40	5.50±0.31	5.96±0.23	6.62±0.31	6.88±0.26
GROUP C	6.82±0.26	6.82±0.26	6.91±0.24	6.91±0.22	6.91±0.22

TABLE 4: The mean salivary pH of the study participants in three different groups at different time intervals after consumption of ORS

GROUP	1 min	5 min	10 min	20 min	30 min
	MEAN±SD	MEAN±SD	MEAN±SD	MEAN±SD	MEAN±SD
GROUP A	4.89±0.45	5.59±0.51	6.37±0.58	6.68±0.47	6.80±0.042
GROUP B	5.44±0.33	5.82±0.27	6.28±0.25	6.78±0.31	7.04±0.21
GROUP C	6.78±0.44	6.96±0.20	6.99±0.15	7.04±0.14	7.04±0.17

TABLE 5: Comparison of mean plaque pH levels between the three groups at different time intervals.

GROUP	1 min	5 min	10 min	20 min	30 min
	MEAN±SD	MEAN±SD	MEAN±SD	MEAN±SD	MEAN±SD
GROUP A	5.25±0.42 *	4.74±0.37 *	5.50±0.39 *	6.19±0.57 *	6.58±0.44 *
GROUP B	5.61±0.40 *	5.50±0.31 *	5.96±0.23 *	6.62±0.31 *	6.88±0.26 *
GROUP C	6.82±0.26 *	6.82±0.26 *	6.91±0.24 *	6.91±0.22 *	6.91±0.22 *
P VALUE	0.000 S	0.000 S	0.000 S	0.000 S	0.030 S

S: Statistically significant if P<0.05, ANOVA test
S, denoted by * NS (Not significant) denoted by **

TABLE 6: Comparison of mean salivary pH levels between the three groups at different time intervals

GROUP	1 min	5 min	10 min	20 min	30 min
	MEAN±SD	MEAN±SD	MEAN±SD	MEAN±SD	MEAN±SD
GROUP A	4.89±0.45 *	5.59±0.51 *	6.37±0.58 *	6.68±0.47 *	6.80±0.042 **
GROUP B	5.44±0.33 *	5.82±0.27 *	6.28±0.25 *	6.78±0.31 *	7.04±0.21 **
GROUP C	6.78±0.44 *	6.96±0.20 *	6.99±0.15 *	7.04±0.14 *	7.04±0.17 **
P VALUE	0.000 S	0.000 S	0.000 S	0.042 S	0.072 NS

S: Statistically significant if P<0.05,
NS: Not statistically significant if P>0.05, ANOVA test
S, denoted by *, NS denoted by **

TABLE 7: Mean comparison of plaque and salivary pH in between groups.

	Groups	1 min	5 min	10 min	20 min	30 min
Difference in plaque pH	A – B	NS	S	S	S	NS
	A – C	S	S	S	S	S
	B – C	NS	S	S	NS	NS
Difference in salivary pH	A – B	S	NS	NS	NS	NS
	A – C	S	S	S	S	NS
	B – C	S	S	S	NS	NS

S: Significant P<0.05, NS: Not significant P>0.05, Post-Hoc Tukey's test

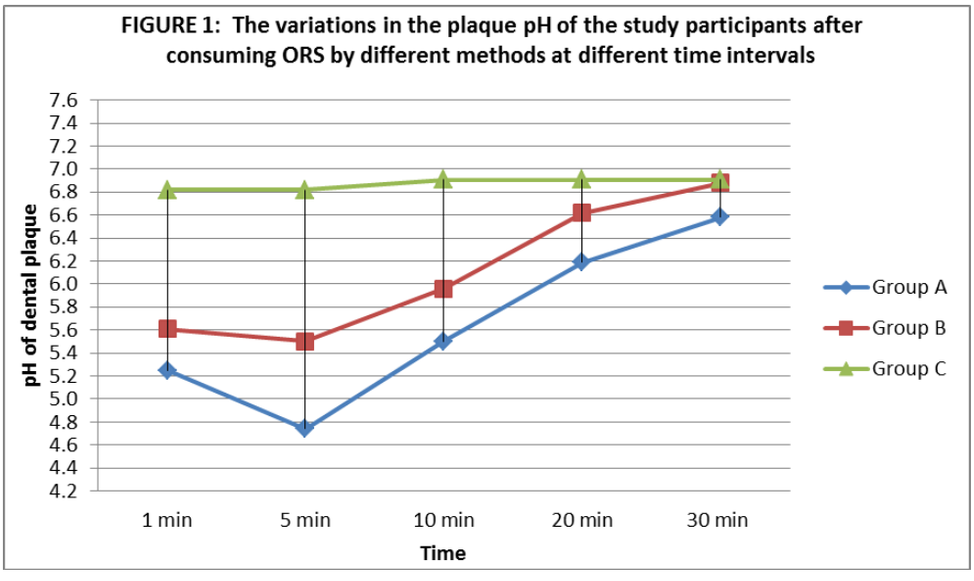

Figure 2: The variations in the plaque pH of the study participants after consuming ORS by different methods at different time intervals

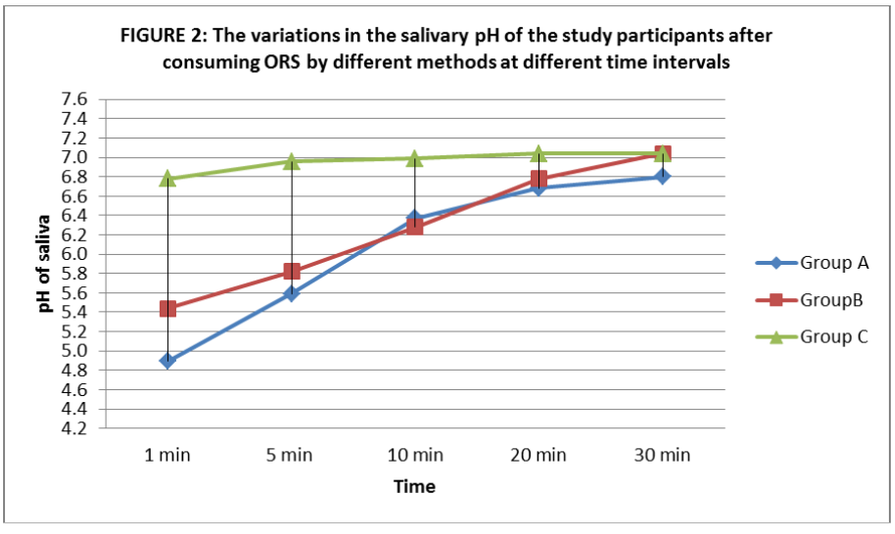

Figure 3: The variations in the salivary pH of the study participants after consuming ORS by different methods at different time intervals