Saliva pH Changes in Patients with High and Low Caries Risk After Consuming Organic (Sucrose) and Non-Organic (Maltitol) Sugar

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ABSTRACT

Introduction: Enamel demineralization is associated with decrease in saliva pH due to fermentation of sugar by oral commensal. Thus, exploring the changing pattern of saliva pH is meaningful in dental caries prevention. The aim of this study was to compare the changing pattern of saliva pH after consuming different types of sweeteners (sucrose and maltitol). **Methods**: It was a case-control study involving 14 male patients attending IIUM dental clinic who were selected with the intention of getting seven patients with high caries risk (DMFT ≥6) and seven patients with low caries risk (DMFT ≤3) with initial saliva pH interval of 6.5 to7.5. Patients were asked to consume snacks containing 8 gram sucrose and 8 gram maltitol as sweeteners. The changing pH values of the saliva were measured by Waterproof pHTestr 10BNC (Oakton, Vernon Hills, USA) seven times consecutively at 0 (before snack consumption), and at 5, 10, 15, 20, 30 and 60 minutes after snack consumption. The pH values of saliva of patients with low and high caries risk after consuming sucrose and maltitol were statistically analized by using Anova and Tukey-HSD tests at α = 0.05. **Result**: There were significant differences in saliva pH changes between low-risk group and high-risk group after consuming sucrose and maltitol. **Conclusion:** The changing patterns of saliva pH in high-risk patients were lower than those of low-risk patients after consuming two types of snacks containing sucrose and maltitol.

KEYWORDS: Saliva pH, sucrose, maltitol, susceptability, dental caries

INTRODUCTION

Dental caries form through a complex interaction over time between acid-producing bacteria and fermentable carbohydrate and many other host factors, including teeth and saliva. The disease develops in both the crowns and roots of teeth, and it can arise in early childhood as an aggressive dental caries that affects the primary teeth of infants and toddlers.[1] The influence of saliva on the caries process is fundamental. In some way, saliva affects all three of the components of Keyes classic Venn diagram of caries aetiology that is tooth, plaque, and substrate.[2] According to the classification of WHO low caries risk group is one having 1.2-2.6 of DMF(t) index; while group having 4.6-6.5 of DMF(t) index is grouped into one with high caries risk.[3]

There is clearly a correlation between low salivary buffer capacity and dental caries experiences,[4] and an additional study[5] reported a similar result, although the data were not quite as strong. Sucrose is one of the main causes of caries formation, since it has low molecular weight and easily dissolved. Thus, it can be quickly fermented by the bacteria and produce extracellular polysaccharide (dextrane and levane) which adheres to the teeth surface.[6,7,8]

Maltitol is a commonly used artificial sugar substitute and often goes by its common registered names of Maltisorb® or Maltisweet®. It is a type of artificial sweetener known as a polyol or sugar alcohol; similar to table sugar in sweetness and texture, but does not promote dental caries and has half the calories in sugar. However, maltitol has side effects and hasn't been studied on humans long enough to know the full extent of any long-term dangers of consuming the sweetener. Until such studies are completed, it may be best to use maltitol in moderation or avoid it altogether.[9]

This study will highlight the factors that cause pH reduction of saliva and the dietary habit. Dietary habit is still the major factor causing dental caries as increase exposure time of sucrose in oral cavity will induce lowering of pH value by fermentation of this substrate by microorganism, especially Streptococcus mutans.[10]

The aim of this study is to investigate and explore the pattern of changes in saliva pH after consumption of different types of sweeteners in persons with high caries risk and low caries risk. The importance of exploring this change is for prevention of dental caries among population.

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MATERIALS & METHODS

The subjects involved in this study were among the community of International Islamic University Malaysia, Kuantan Campus. Written informed consent was obtained from the subjects after the nature of the clinical trial procedures was explained.

14 patients were recruited for the study in selected random sampling with the criteria: male, 20-35 years, patients with low caries risk (DMF-t ≤ 3) and patients with high caries risk (DMF-t ≥ 6), oral cavity pH before treatment is 6.50 - 7.50, non smoker and in a good general health. Sample were divided into two groups; one group was patients with low caries risk, and the other group with high caries risk and each group consisted of seven patients.

On the first day, all patients were asked to brush their teeth using the Roll method[11] for two minutes using the same toothpaste, and they were not allowed to eat and drink for two hours. After two hours, they were asked to sit on a chair and told to spit around ± 2cc of saliva in a reaction tube, or it reached 2 cm from the base of the tube. Then, the pH of their saliva was measured by using waterproof pHTestr 10BNC (Oakton). Afterwards, they were asked to chew 8 grams of snacks containing sucrose for a minute. In the fifth, tenth, fifteenth, twentieth, thirtieth, and sixtieth minute, they were asked to spit again about ±2cc in the reaction tube. Then the saliva pH was measured and recorded. Treatment on the second day, was the same as had been done on the first day. However, the snack containing sucrose was replaced with another snack containing maltitol. The data of saliva pH measurement was statistically analyzed using Anova test, and Tukey-HSD test at α=0.05.

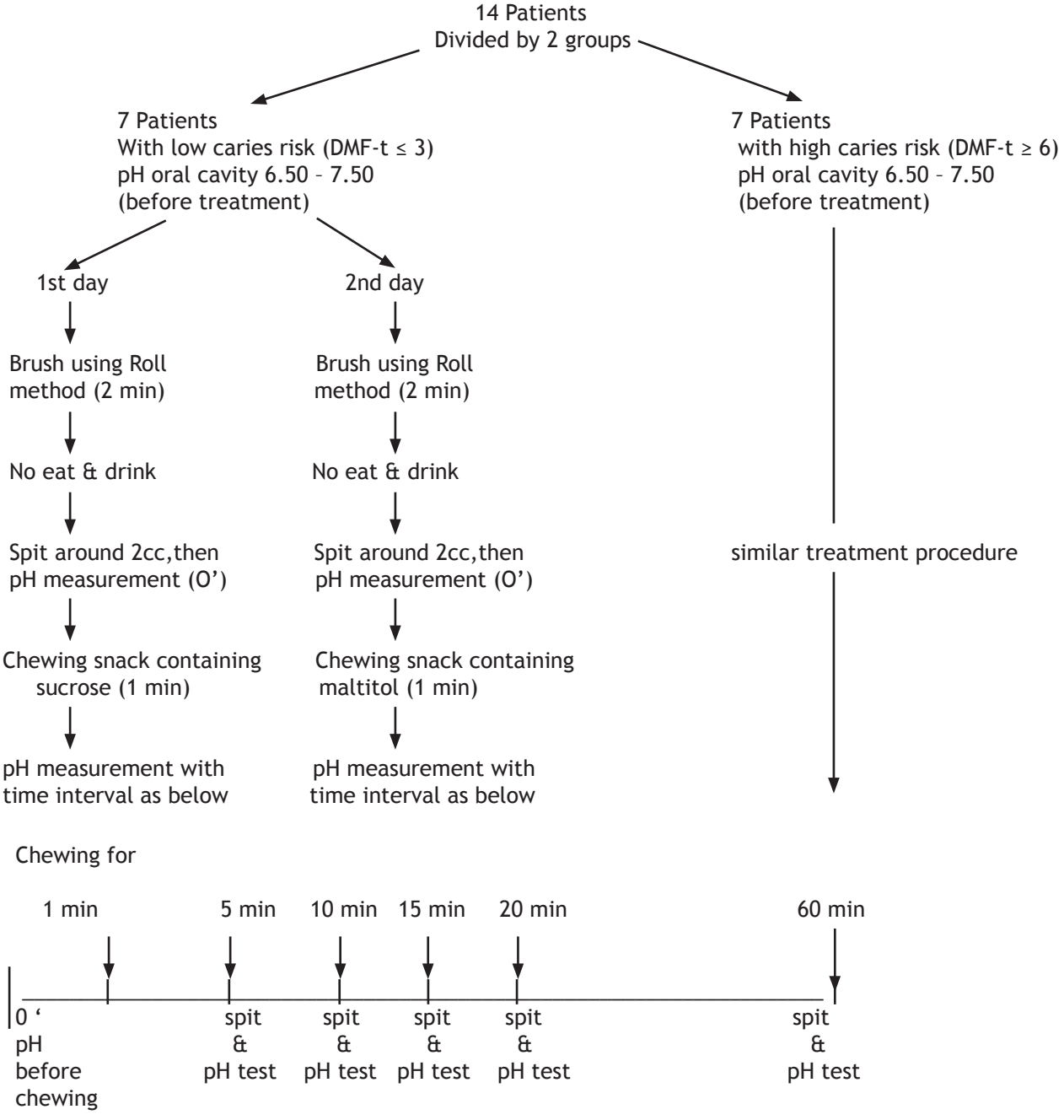

Figure1. Flow chart of treatment procedure

RESULTS

Table 1. The Average value and standard deviation of saliva pH based on the type of caries, the type of sweeteners and the time after chewing of either sugar or maltitol.

Type of Caries	Type of Sweetener	Time	Mean Value	Standard Deviation
Low Caries n = 14	Sucrose n = 7	0 minute	7.3414	.08071
		5th minute	7.1214	.05273
		10th minute	6.9414	.12061
		15th minute	6.8214	.11291
		20th minute	6.8514	.16345
		30th minute	7.0714	.12602
		60th minute	7.2257	.07764
	Maltitol n = 7	0 minute	7.3286	.06466
		5th minute	7.4000	.15022
		10th minute	7.1343	.06876
		15th minute	7.0343	.08080
		20th minute	7.1400	.08832
		30th minute	7.2471	.07499
		60th minute	7.3914	.11097
High Caries n = 14	Sucrose n = 7	0 minute	6.8814	.17430
		5th minute	6.5271	.18319
		10th minute	6.2143	.40307
		15th minute	6.1114	.41835
		20th minute	6.2300	.40336
		30th minute	6.4100	.42802
		60th minute	6.5371	.40442
	Maltitol n = 7	0 minute	6.9943	.16102
		5th minute	6.7900	.16931
		10th minute	6.5843	.15393
		15th minute	6.4629	.14773
		20th minute	6.6200	.17550
		30th minute	6.7586	.16886
		60th minute	6.8957	.15065

Saliva pH in both groups of patients (with low and high caries risks) had the highest pH at the initial time and the lowest pH at the fifteenth minute after consuming snacks containing sucrose and maltitol.

The analysis of variance showed that the type of caries ($F=363.69$; $p=0,00$), type of sweetener ($F=68.88$; $p=0.00$), and time ($F=22.71$; $p=0.00$) after chewing affected the saliva pH. Further analysis by Tukey HSD showed that there was significant change ($p<0.05$) between saliva pH of patients in low and high caries risks. It was also found that there was significant difference ($p<0.05$) in saliva pH after consuming sucrose and maltitol sweetener.

Table 2. Degree of significance in each interval time of patients with low caries after chewing snacks containing sucrose and maltitol

Type of Sweetener	Time (minute after)	0	5	10	15	20	30	60
Sucrose	0	-	0.009*	0.000*	0.000*	0.000*	0.001*	0.453
	5	0.009*	-	0.056	0.000*	0.001*	0.978	0.576
	10	0.000*	0.056	-	0.409	0.728	0.315	0.000*
	15	0.000*	0.000*	0.409	-	0.999	0.002*	0.000*
	20	0.000*	0.001*	0.728	0.999	-	0.009*	0.000*
	30	0.001*	0.978	0.315	0.002*	0.009*	-	0.197
	60	0.453	0.576	0.000*	0.000*	0.000*	0.147	-
Maltitol	0	-	0.799	0.008*	0.000*	0.010*	0.685	0.877
	5	0.799	-	0.000*	0.000*	0.000*	0.063	1.000
	10	0.008*	0.000*	-	0.454	1.000	0.311	0.000*
	15	0.000*	0.000*	0.454	-	0.387	0.371	0.000*
	20	0.010*	0.000*	1.000	0.387	-	0.371	0.000*
	30	0.685	0.063	0.311	0.003*	0.371	-	0.093
	60	0.877	1.000	0.000*	0.000*	0.000*	0.093	-

*indicate significant difference

The results of Table 1, 2 and 3 and Figure 2 showed that the change in the pattern of saliva pH in patients with low caries risk, decreased in the fifth minute after consuming snacks containing sucrose compared to snacks containing maltitol; while the change in pattern of saliva pH of patients with high caries risk decreased in the tenth, fifteenth, twentieth, thirtieth and sixtieth minute after consuming snacks containing sucrose compared to snacks containing maltitol. The decrease of saliva pH in patients with high caries risk after consuming snacks containing sucrose was lower than patients with low caries risk in the fifth, tenth, fifteenth, twentieth, thirtieth and sixtieth minute while decrease of saliva pH in patients with high caries risk after consuming snacks containing maltitol was lower than patients with low caries risk at the interval time of the tenth, fifteenth, twentieth and thirtieth minute.

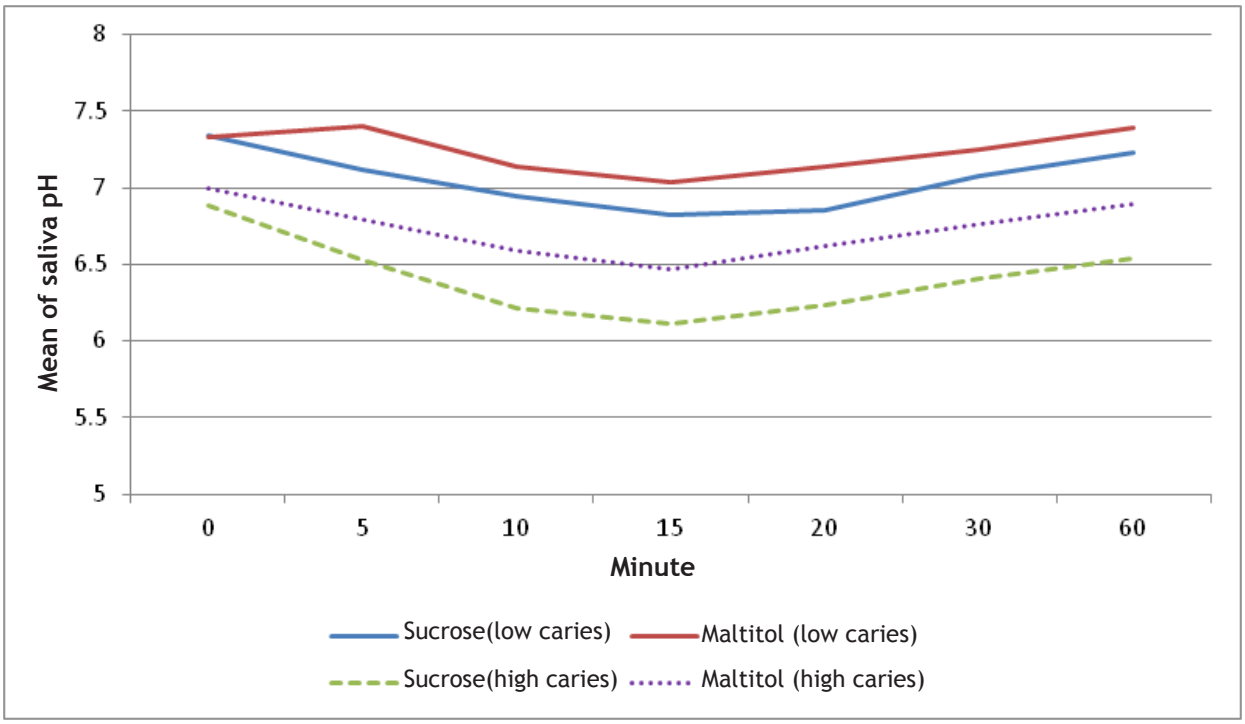

Figure 2. Saliva pH changes after consumption sucrose and maltitol among High caries (n=14) and Low caries (n=14)

Table 3. Degree of significance in each interval time of patients with high caries after chewing snacks containing sucrose and maltitol

	Time (minute after)	0	5	10	15	20	30	60
sucrose	0	-	0.531	0.020*	0.004*	0.024*	0.206	0.565
	5	0.531	-	0.669	0.340	0.719	0.996	1.000
	10	0.020*	0.669	-	0.998	1.000	0.984	0.636
	15	0.004*	0.340	0.998	-	0.996	0.716	0.313
	20	0.024*	0.719	1.000	0.996	-	0.965	0.687
	30	0.206	0.996	0.948	0.714	0.965	-	0.994
	60	0.565	1.000	0.636	0.313	0.687	0.994	-
maltitol	0	-	0.237	0.000*	0.000*	0.002*	0.115	0.911
	5	0.237	-	0.230	0.008*	0.447	1.000	0.880
	10	0.000*	0.230	-	0.794	1.000	0.417	0.013*
	15	0.000*	0.008*	0.794	-	0.541	0.021*	0.000*
	20	0.002*	0.447	1.000	0.541	-	0.679	0.039*
	30	0.115	1.000	0.417	0.021*	0.679	-	0.689
	60	0.911	0.880	0.013*	0.000*	0.039*	0.689	-

* indicate significant difference

DISCUSSION

The analysis of variance proved that patients at low caries risk have saliva pH higher than patients with high caries risk, after consuming snacks containing sucrose. Their saliva pH decrease more compared to saliva pH after consuming snacks containing maltitol. In the tenth, fifteenth, twentieth, and the thirtieth minutes, there were significant changes in saliva pH compared to the initial pH (the zero minute).

This study proves that patients having high caries risk have significant lower saliva pH compared to the patients with low caries risk; which is in accordance with the previous research.[4]

The type of sweetener in the snacks also affects the saliva pH, and this is shown by the decrease of saliva pH after patients consumed snacks containing sucrose compared to of those who consume snacks containing maltitol. This may be because Streptococcus mutans cannot change maltitol into acid due to the absence of essential enzymes, even though maltitol can penetrate into the membrane of bacteria cell that reduces the activity of the glucosyltransferase.[12] Sucrose can easily be fermented into lactic acid and piruvic acid. Thus, increasing the enzymatic activity of glucosyltransferase.[13]

This extracellular enzyme catalyzes the glucosyl-transferase derived from sucrose, and it develops into glucan polymer and combines with the glucan binding protein to support the adherence of Streptococcus mutans to the teeth and the cell aggregation.[12] Cariogenic bacteria such as Streptococcus mutans can use monosaccharide components (glucose and fructose) that are separated from disaccharide sucrose and energy derived from the bounding of the disaccharide to collect extracellular polysaccharide. This situation can accelerate the increase of plaque thickness, causing acidic environment of the teeth; and therefore, difficult to overcome by the buffer saliva and increases the risk of caries.

After consuming the sucrose type sweetener, the saliva pH decreased lower compared to consuming the maltitol type sweetener which cannot be fermented into acid.[14] Generally, the pattern of saliva pH in patients having caries will show a decrease at the time intervals of the fifth, the tenth and the fifteenth minute and then increase again at twenty and thirty minutes after consuming snacks. At the sixtieth minute, the saliva pH is nearly the same as the initial pH. This is in accordance with some researchers [8,12-14] who stated that the lowest pH occurs in about five to twenty minutes after consuming sucrose, and then gradually returns to normal. Saliva pH of patients having low caries risk increased at the fifth minute after consuming snacks containing maltitol. This may be caused by the calcium content found in milk, sodium bicarbonate and potassium in the snack having alkaline properties.[8,15,16,17]

The decrease in saliva pH at the fifth to fifteenth minute is due to of the presence of lactate and piruvic acids. The fermentation products of carbohydrate by the acidogenic bacteria cause the saliva pH to decrease. The decrease of saliva pH was above 5.5 as this study used the carbohydrate composition instead of pure sucrose; and it also

consists of flour with polysaccharide type that is difficult to ferment. The increase of saliva pH after 20 minutes is caused by the capacity of saliva as a buffer that can neutralize acid thus; this can avoid the demineralization process. The balance between demineralization and remineralization can be quickly reached using high flow of saliva as an effective buffer.[17]

The changing pattern of saliva pH in patients with low caries risk after consuming snacks containing sucrose shows a decrease at the time interval of the fifth, the tenth, and the fifteenth minute, and increased again in the twentieth and the thirtieth minute. At the sixtieth minute, the saliva pH was nearly same as the initial pH. While the analysis of the change in pattern of saliva pH of patients with low caries risk after consuming snacks containing maltitol shows the decrease at the time interval of tenth and fifteenth minutes. However, it started to increase at the twentieth minute. At the thirtieth and sixtieth minute, the saliva pH decreased till it reached the initial pH.

The pattern analysis of saliva pH in patients with high caries risk after consuming snacks containing sucrose and maltitol shows a decrease at the time interval of tenth and fifteenth minute, and start to increase again after twenty minutes. In the thirtieth and sixtieth minute, the saliva pH was close to the initial pH. The absence of significant difference in the low caries risk patients in the tenth, fifteenth, twentieth, thirtieth and sixtieth minute after consuming snacks containing sucrose and maltitol shows that the change in pattern of the saliva pH in the low caries risk is all the same at the time interval of the tenth, fifteenth, twentieth, thirtieth and sixtieth. This complies with the study[16] that showed that there were no differences of saliva pH change between chewing gum containing sucrose and sorbitol. Significant difference can only happen in patients with low caries risk at the fifth minute, where their saliva pH decreases lower after consuming snacks containing sucrose compared to maltitol. Saliva pH increasing at the fifth minute after consuming snacks containing maltitol might be caused by the alkalinity of the milk calcium, sodium bicarbonate, and potassium in snacks. Patients with high caries risk show their saliva pH decrease significantly lower after consuming snacks containing sucrose compared to snacks containing maltitol at the time interval of tenth, fifteenth, twentieth, thirtieth and sixtieth minute.

This is caused by sucrose being synthesized by Streptococcus mutans forming glucan that has an important role in bacteria metabolization. Furthermore, sucrose can also be fermented homolactically into one glucose molecule and one fructose molecule; later, the glucose is separated into two molecules of lactic acid as the end product. This acid production can reduce the saliva pH.[13] On the other hand, maltitol cannot be fermented by most organisms inside the mouth; so it could not produce essential acids.[12,14] There is more acid formation when consuming snacks containing sucrose compared to those containing maltitol. This causes the pH saliva to decrease even lower.

The insignificant difference at the fifth minute after consuming snacks containing sucrose or maltitol was maybe because of the formation of acid is still at the same level. The significant difference of saliva pH between the patients having low and high caries risks in the fifth, tenth, fifteenth, twentieth, thirtieth, and sixtieth minutes after consuming snacks containing sucrose shows that the decrease of saliva pH in patients having high caries risk is more pronounced at the time interval of fifth, tenth, fifteenth, twentieth, thirtieth, and sixtieth minutes from the initial pH (0 minute) compared to the patients having low caries risk. This might be because of those patients with high caries risk have lower initial saliva pH and also have more amounts of bacteria compared to the patients with low caries risk; so the acid formed increases after consuming snacks containing sucrose.

It was shown that the change in the pattern of saliva pH in patients having high caries risk would be even lower at the time interval of tenth, fifteenth, twentieth, thirtieth, from the zero minute compared to the patients having low caries risk after consuming snacks containing maltitol. This may happen since patients having high caries risk take a longer time to neutralize acid. Thus, the saliva pH also took more time to return to the initial pH. The decrease of saliva pH at the fifth minute in patients with high and low caries risks after consuming snacks containing maltitol are on the same level; this might be due to the same amount of the acid formation initially. The increase of saliva pH at the sixtieth minute in both high and low caries risks patients close to the initial pH because maltitol is easily neutralized by the saliva buffer.

CONCLUSION

The change in the pattern of saliva pH in patients having high caries risk decreased more compared to patients having low caries risk, both after consuming snacks containing sucrose and maltitol. This study supports the usage of maltitol as sugar replacement since it can reduce the incidence of dental caries,[12-14] and there were no symptoms seen when using doses of less than 50 g per day.[18] Moreover, previous study stated that maltitol was well tolerated in children at 15 g in one intake.[19] However, further research must also be undertaken to study regarding the precise safety dose of maltitol in the form of snack and / or chewing gum due to the fact that the saliva pH will return to normal within one hour and it should include the other group of patients with very low, low, moderately low, high and very high caries risks. Other types of sugar substitutes may also be investigated, for their use as an alternative to sucrose in the food and beverage industries.

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