Original Article

pH of Commercially Available Brands of Toothpaste and Mouthwashes in Sulaimani/ Iraq Markets: An In-vitro Study

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Abstract

Objective: The pH of the daily used toothpaste and mouthwashes dramatically affects the balance of the demineralization and remineralization processes on the tooth structure. Yet, its value is not labeled on the container for public.The aim of this study is to measure the pH values of various toothpaste and mouthwashes those are commercially available in Sulaimani market.

Methods: The pH value of twenty-one toothpastes and fifteen types of mouthwash commercially available in Sulaimani were measured twice by using JENWAY pH meter. The electrode immersed inside the tested sample (10 mL mouthwash and 2mg/10 mL toothpaste) for 3 minutes. The pH mean value for each sample was calculated.

Results: The pH mean value for toothpaste and mouthwashes were 7.67 and 6.33, respectively. Low pH values were reported in Vitis-ortho (4.94), and Desensin repair toothpaste (6.99) and high values reported in A.ME menton &calcium toothpaste (8.85) and Nano-whitening mouthwash (7.855).

Conclusions: The pH of toothpaste was neutral to slightly basic. Thus their repeated use is considered as none erosive. While the pH of mouthwashes was acidic or somewhat optimal, that indicates the possibility of enamel erosion with frequent use. Thus a careful mouthwash's type selection is required.

Keywords: *pH, Toothpaste, Mouthwash, Sulaimani.*

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Introduction

The pH of toothpaste and mouthwashes is a crucial variable that plays a role in enamel demineralization. However, pH alone is not a good indicator for the erosive potential of oral hygiene products; the erosion process may depend significantly on the degree of saturation, consistency, and duration of their contact with the tooth surface[1]. Furthermore, toothpaste hardness and abrasiveness, besides brushing frequency; stiffness bristle; pressure applied are all responsible for erosive tooth wear[2,3]. On the other hand, host factors also plays a role in dental hard tissue demineralization such as the fluoride concentration of the hard tissues, pellicle and plaque formation, as well as calcium fluoride precipitation on the surfaces of the teeth[1], the flow rate and buffering capacity of saliva, the manner and frequency of consumption of erosive[4].

The pH scale describes the chemical level of acidity and alkalinity of any substance. It ranges from 1 (acidic) to 14 (alkaline), and seven being neutral[5,6]. Researchers documented that acidic pH induces loss of dental tissues[4,7–9]. The critical pH below which tooth structures demineralization occur is not constant[8]. Enamel demineralization starts at pH between 5.2–5.5[7] and pH for dentin demineralization range between 6–6.9.[10]. Whereas, enamel remineralization occurred at pH 5.6–5.8 in the presence of calcium and phosphate saturated saliva together with fluoride (pH between 4.5 and 5.1)[10,11], therefore, a slightly acidified fluoridated dentifrices have a particularly positive effect on enamel remineralization[12], however, re-hardening of softened dental hard tissue takes hours to days[4]. On the other hand, enamel exposed to high alkaline solutions results in a degradation of the protective organic layer at the surface that profoundly increase the risk for dental erosion from acidic intake[13]. However, the oral pH is maintained near neutrality (6.7–7.3) by the buffering capacity of saliva[14]. But people with low salivary concentrations of calcium and phosphate, the critical pH maybe 6.5, whereas, in those with high salivary calcium and phosphate concentrations, it maybe 5.5. A rise in salivary pH is unrelated to its baseline pH, salivary flow rate, buffer capacity, or subject age[1], and a simple plain water mouth rinsing (10-15mL) is effective in reducing salivary pH[14].

Toothpaste is a semi-solid material used simultaneously with a toothbrush to remove deposits from teeth. A mouthwash is a non-sterile aqueous solution; an add-on oral hygiene products used for therapeutic indications[15]. Both toothpaste and mouthwashes used to reduce oral bacteria, remove food particles, temporary reduce halitosis, provide a pleasant taste, and reduce plaque or fight cavities[16]. A healthy oral environment can be achieved and maintained by thorough brushing and regular rinsing with keeping in mind that the dentifrice and mouth rinse pH range might influence the pH of saliva. An in-vivo study showed that salivary pH became alkaline immediately after using alkalized toothpaste and mouthwash[17], and combined use of fluoridated TP and mouthwashes increases the pH of saliva in children more than toothpaste alone[18]. Mouthwashes can return salivary pH to neutral baseline values after acidic drink within 15 min, and two-step mouthwash rinse gives better results than a single rinse[19].

Concerning the ingredients of toothpaste and mouthwashes, they varied from product to the other, over time, from one manufacturer to another and in different countries. Some mouthwashes have the same composition as toothpaste but without abrasives and contain 18-26% alcohol[16]**.** The choice of these products depends on the customers, manufacturers, and dental care professionals' viewpoint. There is a gap in knowledge regarding the pH value of oral health products. Most of the manufacturers do not indicate the pH on their products. Various scientific researches provide data on the pH of different types of toothpaste[2], mouthwashes[20–22]. Many studies investigated pH of various products available in the market at a certain period of time. Therefore, it was considered as an important issue to have enough knowledge about pH level of most of toothpastes and mouthwashes available in Kurdistan region/Iraq in general and in Sulaimani Governorate in particular. In the current study, we focused on measuring the pH level of commercially used toothpaste and mouthwashes as they are not labeled on the packaging.

Materials and methods

The studied sample consisted of twenty-one commercial toothpastes and fifteen types of mouthwash based on their availability in our regional market (Sulaimani/ Iraq). The popularly used toothpaste and mouthwashes brands include Biorepair, VITIS, Kin, Crest, Close Up, Sanino, Colgate, A.ME, Zak, Al-Mansour, Nano, and BlanX. The pH measurements were done in the laboratory of the college of Science/department of chemistry/Sulaimani University by using the JENWAY, 3345 Ion meter.

The pH meter was initially standardized using buffered solutions of pH 4 and 7 and was re-calibrated before testing each new product at room temperature 25°C ± 2°C. All samples were tested in duplicate to obtain mean pH values. Ten milliliters from each mouthwash was poured in a clean, dry disposable cup, and the pH electrode immersed inside it, maintained approximately for three minutes in each solution while stirring to allow

uniform contact with the electrode tip and avoiding air bubbles formation or touching the base of the container to prevent false results. Then the electrode rinsed thoroughly with distilled water and dried with wipes and re-immersed in the same sample or a new sample. To measure the pH of the toothpaste we prepared the test samples as aqueous suspensions by thorough stirring 2.0 mg of the first portion from every new tube for each sample of toothpaste with 10 mL tap water in a clean disposable cup, for 2 minutes using glass rode at 25° C ± 2°C. The pH level was grouped into; very acidic =4.0–5.5, acidic=5.6-6.4, optimal=6.5-7.5, Neutral=7.6-7.9, and alkaline≥ 8[14].

Statistical analysis

An Excel worksheet was used to tabulate the data, and statistical software package (SPSS for Windows v.16; SPSS Inc) was used for analyzing. The frequency and percentage distributions were calculated for non-parametric variables. Shapiro-Wilk was used for tests the normality of pH values, then the mean ± SD were calculated, and variances among groups were analyzed by ANOVA test. A p-value≤ .05 was considered significant.

Results

The 36 samples (21 toothpastes and 15 mouthwash) belonged to 11 manufacturers. VITIS products constituted the majority of the total samples (36.1%,

predominantly mouthwash) followed by Kin (27.8%) and Biorepair (11.3%). Nevertheless, the Kin's toothpastes were more than VITIS (33.3% vs. 23.8%), (Table 1).

The pH value of the studied dentifrice aqueous solutions ranged between 6.99 for Densensin repair and 8.85 for A.M.E Menton & Calcium, while the pH range of mouthwashes was 4.4 for VITIS ortho and 7.85 for Nano whitening. The pH value and category distribution for the brand names of oral hygiene products presented in table 2. Most toothpaste (n=16) 76.2% were within neutral and optimal pH (42.9% optimal pH with a mean of 7.26 ± 0.25 and 33.3% neutral, with an average of 7.74 ± 0.06). But 23.8% of the samples had basic pH ≥8 (8.35 ± 0.29). There was no acidic or highly acidic tested toothpaste located below the critical threshold for demineralization (Table 2). On the other hand, 53.3% of mouthwashes had a significant acidic pH value. There was no alkaline mouthwash. The mean pH of all rines was 6.34±1 and was significantly differed from that of total toothpaste (7.68±.49, P=0.000). The mean pH of the tap water was 6.9.

In the context of redistribution of oral hygiene products related to the reason for their prescription, results showed seven therapeutic categories (table-3). The sample consisted of 23.8% anti-caries toothpaste followed by equal distribution for toothpaste prescribed for kids (19%) and teeth whiting (19%). Moreover, the most frequently tested mouthwash was that used for anti-gingivitis (46.7%) followed by anti-caries and whiting mouthwashes (each constituted 13.33%).

There was no statistical variation in pH group among the types within dentifrices or rinses separately. However, a significant finding (p=0.05) was seen between the breath refreshing toothpaste (7.28±.22) and mouthwash (6.16±.05). Mouthwash for kids, whitening, and anti-caries only located within optimal pH. While anti-gingivitis, anti-sensitivity, breath refresher, and orthodontic treatment all were acidic mouthwashes.

Table 1: Frequency distribution and percentage of the total sample according to their manufactures.

	Manufacturers	Toothpaste		Mouthwash		Total	
		n	%	n	%	n	%
1	Coswell Innovatori Italiani, Italy Biorepair	3	14.3	1	6.66	4	11.1
2	DENTAID S.L Cerdanyola, Spain Vitis	5	23.8	8	53.36	13	36.1
3	LABORATORIOS Kin S.A , Barcelona Spain Kin,	7	33.3	3	20	10	27.8
4	Procter & Gamble GmbH, Germany. Crest	2	9.52			2	5.56
5	Egypt/Unilever Mashreq-Personal Care Company Close up	1	4.76			1	2.78
6	Evyap company - Istanbul, Turkey Sanino	1	4.76			1	2.78
7	COLGATE-PALMOLIVE (China) Co.,Ltd. Colgate (Max white)	1	4.76			1	2.78
8	GALIEN CHEMICAL INDUSTRIAL co.Ltd. China A.M.E menton &calcium	1	4.76			1	2.78
9	Panax Pharma, Egypt- Zak			1	6.66	1	2.78
10	Almansour Company, Baghdad, Iraq- Al Mansour			1	6.66	1	2.78
11	WhiteWash Laboratories, United Kingdom- Nano whitening			1	6.66	1	2.78
	Total	21	100	15	100	36	100

Table 2: Frequency distribution of 21 toothpaste and 15 mouthwash brand name products according to their acidic category* and their rank in ascending manner depend on their pH value.

	Acidic pH=5.6-6.4		Optimal=6.5-7.5		Neutral=7.6-7.9		Basic/alkaline≥8	
	Brand name of products	pH	Brand name of products	pH	Brand name of products	pH	Brand name of products	pH
Toothpaste			Densensin repair	6.68	Fluor Kin calcium	7.64	Blanx Med	8.085
			Crest Complete	7.02	Vitis anticaries	7.645	Vitis Junior	8.15
			Crest-cavity protection	7.245	Biorepair care pro	7.685	Kin progressive whitening	8.34
			Fluor Kin anticaries	7.325	Vitis whitening	7.72	Colgate (Max white)	8.365
			Kin gingival	7.325	Kin B5	7.79	A.M.E menton &calcium	8.835
			Sanino	7.375	Sensikin	7.81		
			Vitis halite	7.38	Kin Ortho	7.85		
			Close up	7.43				
			Biorepair Junoir	7.505				
Mouth wash	Vitis ortho	4.4	Vitis perio aid (0.12 CHX)	6.675	Bio repair MW	7.635		
	Vitis gingival	4.94	Kin calcium	6.945	Nano whitening	7.855		
	Desensin Repair	5.37	Tap water	6.9				
	Vitis whitening	5.495	Kin B5	6.99				
	Al Mansour chlorhexidine	5.73	Vitis anti-caries	7.005				
	Vitis Halita	6.16	Kin gingival	7.32				
	Vitis perio aid Maintenance CHX 0.02%	6.215						
	Zak MW	6.36						

Table 3: Frequency distribution of acidic category and mean pH value of toothpaste and mouthwash products in relation to their specific therapeutic indication.

		Total		Specific therapeutic indication							p value
		n	%	Anti-caries	Whitening	Anti-gingivitis	Sensitivity	Breath freshener	Kids	Ortho. treatment	
toothpaste	alkaline ≥8	5	23.8	1	3	0	0	0	1	0	
	neutral 7.6-7.9	7	33.3	2	1	1	1	0	1	1	
	optimal 6.5-7.5	9	42.9	2	0	1	1	3	2	0	
	Total n (%)	21	100	5 (23.8 %)	4 (19.04%)	2 (9.5%)	2 (9.5%)	3 (14.28%)	4 (19.04 %)	1 (4.76%)	
	mean±.SD	7.68±.49		7.75±.63	8.13±.3	7.56±.32	7.25±.79	7.28±.22	7.67±.34	7.850	.311**
mouthwash	neutral 7.6-7.9	2	13.3	1	1	0	0	0	0	0	
	optimal6.5-7.5	5	33.3	1	0	3	0	0	1	0	
	acid 5.6-6.4	8	53.4	0	1	4	1	1	0	1	
	Total	15	100	2 (13.33 %)	2 (13.33%)	7 (46.66%)	1 (6.66%)	1 (6.66%)	1 (6.66%)	1 (6.66%)	
	mean±.SD	6.34±.1		7.32±.45	6.67±.12	6.3±.08	5.37±.3	6.16±.05	6.94±.15	4.400	.316**
p* value		.000		.437	.127	.079	.306	.050	.153	.000	

Discussion

Teeth that have suffered acid erosion cannot be remineralized; it is irreversible, permanent tooth loss[8]. The evidence shows that the prevalence for dental hard tissue dissolution by acid has increased[4], and is currently considered to be a significant oral disease and a focus of growing interest both in clinical dentistry and in research[4,10,23–26]. Both critical acid or alkaline oral hygiene products initiated temporary oral environment alteration[1] that is harmful to tooth structures, implants, fissure sealants, composite restorations and orthodontic wire over time[14,25,27–31].

Literature indicates that more than 79% of dentifrices have a neutral or basic pH, and only 10% of the market dentifrices are of acidic or highly acidic pH level. But 21% of them are below the critical threshold of demineralization of dentin and cementum (pH of 6.5)[31]. The outcomes of our study showed that the pH of 21 kinds of toothpaste ranged from slightly neutral to basic, and there was no acidic toothpaste (pH range 6.68-8.83) when compared with the result obtained by Lavoie et al. in their study that included 200 kinds of toothpaste available on the Canadian market. Most of their toothpaste (> 80%) were neutral, and only 15% were acidic or highly acidic products located below the critical threshold for demineralization[2]. Similar results were reported in a Brazilian study, in which the authors showed that the pH of 19 dentifrices brands ranges between 6.8–9.9[32]. Whereas, Shaik et al. in their study found that the pH of different commercially available alcohol-containing mouthwashes was acidic, with a range of 3.84-6.50[15], and salivary pH increase significantly after sodium bicarbonate oral rinse[33].

Nevertheless, saliva has a significant buffering capacity that neutralizes oral pH[1,15]. Besides, adding small amounts of calcium to acidic solutions may decrease enamel loss by up to 50%[34]. In-vivo the balance between demineralization and remineralization is depended on salivary calcium and phosphate concentration, the bioavailability of fluoride, and pH level. When the pH raises, calcium, and phosphate with fluoride form new hydroxyapatite crystals[10,34]. Therefore, low pH is a desirable characteristic in fluoride toothpaste[31].

In-vitro measuring the pH of oral hygiene products alone does not present the real biological system and could not represent an inclusive indicator for its erosive potential because there is no saliva in which the dentifrice needs to be dissolved, and it misses its buffering effect. Although there are considerable differences among toothpaste dilution and the uniformity of their composition, a toothpaste gets 22% initially dilution with saliva, and 59% of it will be spat out after 30seconds[35]. On the other hand, mouthwashes solutions directly mix with saliva and recommend to be swished around in the mouth for 30 seconds to one minute then spit out followed by avoiding eating or drinking for at least 30 minutes. There is a limited number of in-vivo studies assessed the fluctuation in oral pH after mouthwashes rinsing[1,17–19]. Nevertheless, in-vitro, acidic mouthwash produces dental erosion[20,36,37] and in vitro oral rinses with pH below 6 can lead to significant enamel loss within the first few minutes of contact[15].

All of the manufacturers of the studied brands do not label or mention the pH level on their products. It is essential to identify the pH level of oral hygiene products since it is recommended to be used frequently and daily. It is a critical situation when a person brushes with low pH toothpaste or rinse with acidic mouthwash[20] twice a day on average and for several minutes as it consequently result in more erosion. Moreover, some products are even intended for swishing or being held in the mouth for as long as possible to ensure their effectiveness. Therefore, oral hygiene products must have physical-chemical characteristics that allow for their therapeutic effect without potential damage to oral tissues. Ideally, they should have a relatively neutral pH. According to the results of the present study, the impact of our limited samples of toothpaste brands collected from the regional markets in Sulaimani city is safe for dental hard tissue structures.

On the other hand, the results of pH level for mouthwashes range from basic to acidic, most falling in the acidic category. The most acidic mouthwash in our research was VITIS Ortho (pH of 4.4) which is used by orthodontic patients regularly, to prevent plaque retention on the wires and brackets. Accordingly, the constant use of such acidic mouthwash will increase the risk of demineralization and caries and increase corrosion and release of nickel and chromium ions from orthodontic wires[30]. Furthermore, in-vivo studies are needed to reassess these undesirable effects of acidic mouthwash and compare different brands that are specifically recommended for orthodontic patients to serve those patients with safer products.

Currently, most people want to have an attractive smile, white, and healthy teeth. They directed to use tooth-whitening paste and mouthwashes. Fortunately, all

tested whiting toothpastes were alkaline, with a range of 7.72 for VITIS whiting to 8.36 for Colgate (Max white). These results were in line with the pH values reported for whitening toothpaste from South African market, they ranged from 6.61 to 9.68, and Colgate advance whiting had a pH of 9.68[38]. On the other hand, Nano whitening mouthwash had an alkaline pH (7.85) while the VITIS whiting mouthwash had acidic pH (5.495) that may be related to different concentrations of hydrogen peroxide or carbamide peroxide ingredients. It seems that a combination of VITIS products for teeth whiting is a little bit confusing they have contrary or opposite pH level.

Both toothpaste and mouthwashes used for caries prevention had nearly similar optimal pH, unlike the antiseptic products used for controlling dental plaque and preventing gingivitis. The toothpaste had optimal pH, but 57% of mouthwashes were acidic; VISITS gingival had the lowest pH (4.94) followed by Al-Mansour CHX (5.73), VITIS Perio AID Maintenance 0.02% CHX (6.21) and ZAK CHX (6.36). Chlorhexidine MW has acidic pH (5.1)[22] similar to our results except for VITIS Perio AID, 0.12 % CHX had optimal pH (6.67). To gain a mouth free from dental plaque, chlorhexidine MW is recommended to be kept in the mouth for a minute and be used twice daily. It adsorbs firmly to the oral tissue due to its potent cationic agent, and its release extends for 12 hours. Therefore, further observational in vivo studies are needed on such mouthwash and its role in tooth demineralization and remineralization with the possible effect of this acidic environment on the action of the therapeutic ingredients. It is worth to mention that Kin gingival toothpaste and mouthwash had similar pH (7.32) and KIN B5 toothpaste had a little higher pH (7.79) than KIN B5 mouthwash (6.99).

pH is the primary regulating factor in the formation of bad breath. Acidic oral environment minimizes the production of bad odors while neutrality and alkalinity increase it. For that reason, it would be logical that mouth rinses provide a reduction of saliva pH to reduce halitosis[39]. This finding is in line with our result in which the single tested mouthwashes (VITIS Halita) had pH 6.16 while the pH of breath refreshing toothpaste ranged between 7-7.43. Again the pH of VITIS Halita mouthwash was acidic, and its toothpaste was alkaline.

Moreover, toothpaste for sensitivity was either being of neutral or optimal pH (Sensi Kin 7.81 and Desensin repair VITIS 6.68), while the anti-sensitivity mouthwash (Densensin repair VITIS) was acidic (5.37). Finally, all oral hygiene products for kids were within neutral and optimal pH except VITIS Junior and Fluor Kin calcium were alkaline (pH = 8.15 and 7.64 respectively). Mouthwashes are not usually recommended for young children to avoid problems related to accidental swallowing.

Although a mouth rinse increases salivary pH above the threshold level is needed for prevention of enamel demineralization and enhancing remineralization, the dentist should not forget that a neutral or basic oral pH level promotes the mineralization of biofilm and increase the formation of calculus. Therefore, a proper brushing precedes mouthwash rinsing is a must to remove this biofilm layer.

The selection of the proper toothpaste guided by the dentist depends on the patient's need and the pH balance to avoid possible long-term harmful effects.

Conclusions

Most kinds of our studied dentifrices are non-harmful for dental structures, unlike mouthwashes that need a particular concern during their prescription as an adjunct to oral hygiene measures for long periods and through the maintenance phase. We recommended avoiding the use of acidic mouthwashes for too long and too frequently as it weakens the teeth.

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