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Experimental Article

Changes in salivary pH following consumption of different varieties of date fruits

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الملخص

أهداف البحث: أظهرت الأدبيات أن استهلاك ثمار التمر يؤدي إلى تغيرات كيميائية في اللعاب، بما في ذلك تغيرات في قيم الأس الهيدروجيني. وقد أُجريت هذه الدراسة لتقييم تأثير استهلاك أنواع مختلفة من ثمار التمر على درجة الحموضة اللعابية.

طرق البحث: جندت هذه الدراسة ١٥ طفلا (العمر من ٦-١٥ سنة) وطُلب منهم تناول قطعة واحدة من نوع معين من التمر (صفري ونبتة سيف وخلاص وسكري وصقعي) لمدة ٥ أيام متتالية. في اليومين السادس والسابع، أكل الأطفال ربع حبة جريب فروت (تحكم إيجابي) ومضغوا على كرة صغيرة من القطن المعقم (تحكم سلبي)، على التوالي. تم جمع عينات من اللعاب غير المحفز من الأطفال على الأقل ساعة واحدة بعد الإفطار كل يوم وتم تسجيل الرقم الهيدروجيني اللعابي.

النتائج: عند مقارنتها بِقِيَم الأس الهيدروجيني قبل استهلاك التمر، لوحظ أدنى متوسط لقيم الأس الهيدروجيني اللعابي بين مجموعات التمور عند ٥ دقائق، بعد استهلاك الخلاص (٦.٢٦) متبوعا بالصفري (٦.٣١) ونبتة سيف (٦.٣٦) والصقعي (٦.٤٤) والسكري (٦.٤٥). وقد أظهر الخلاص (٠.٤٧) أعلى فرق في القِيَم المتوسطة، يليه السكري (٠.٤٥)، ونبتة سيف (٠.٤٤)، والصقعي (٠.٣٨)، والصفري (٠.٣٥). وكان الرقم الهيدروجيني للعاب الذي تم جمعه بعد أكل ربع جريب فروت هو الأقل، بينما أدى مضغ كريات القطن إلى زيادة درجة الحموضة اللعابية.

الاستنتاجات: أظهرت هذه الدراسة انخفاضا في الرقم الهيدروجيني للعاب بعد استهلاك التمر، وإن لم يصل إلى القيمة الحرجة. تشير هذه النتائج إلى أن التمور لا تحمل تأثيرات ضارة على علامات اللعاب.

الكلمات المفتاحية: تمر؛ درجة الحموضة؛ اللعاب؛ السكريات؛ ثمار التمر

Abstract

Objective: Consumption of date fruits leads to chemical changes in saliva, including variations in pH values. We conducted this study to assess the effect of the consumption of different types of dates on salivary pH.

Methods: We recruited 15 children (aged 6–15 years) who were instructed to consume one piece of specific types of dates (Safree, Nabtat Seif, Khalas, Sukkari, and Segae) for 5 consecutive days. On the 6th and 7th days, the children consumed a quarter of a grapefruit (positive control) and chewed on a sterilised cotton pellet (negative control), respectively. Salivary samples from unstimulated kids were collected at least 1 h after breakfast every day and the salivary pH was recorded.

Results: When compared with the pH values before date consumption, the lowest mean salivary pH value among the date-consuming groups 5 min after salivary stimulation was noted after the consumption of Khalas (6.26), followed by those after consumption of Safree (6.31), Nabtat Seif (6.36), Segae (6.44), and Sukkari (6.45). The highest difference in mean values was observed for Khalas (.47), followed by those for Sukkari (.45), Nabtat Saif (.44), Segae (.38), and Safree (.35). The pH of saliva collected after grapefruit consumption was the lowest,

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whereas chewing cotton pellets led to an increased salivary pH.

Conclusion: This study showed a decrease in the salivary pH following date consumption, but not to a value as low as the critical value. These findings suggest that dates do not have detrimental effects on salivary parameters.

Keywords: Dates; Date fruit; pH; Saliva; Sugars

Introduction

Date palm (*Phoenix dactylifera*) is a fruit of the date palm tree, an evergreen tropical plant that belongs to the Arecaceae (Palmae) family,[1] and is mainly cultivated in Egypt, KSA, Iran, and Iraq.[2] The cultivation of this fruit as a source of food known to and adopted by man dates back to over six millennia.[3] It is the only fruit to be consumed as a staple diet by millions of people over thousands of years owing to its delicious and highly nutritious nature.[4]

There are more than two hundred varieties of dates available worldwide.[5] They are mainly produced in the hot deserts of Southwest Asia and North Africa, and are considered as one of the chief commodities in the market throughout the world. This low-cost food is likely to hold its sway in the market due to the continuously widening gap between food supply and demand.

Some of the commonly used variety of dates that possess high medicinal values owing to their anti-oxidant, anti-inflammatory, and anti-bacterial properties include Khodry, Khalas, Ruthana, Sukkary, Safree, Segae, Ajwa, Hilali, and Munifi.[6]

Humans have been captivated by the concept of health since time immemorial, probably soon after the discovery of 'fire' and its benefits. The motto "healthy eating is most important" has been adopted over the past several centuries.[7] It is a well-established fact that a good balanced diet is imperative for the development and upkeep of healthy teeth, which are, in turn, affected by optimal salivary parameters. The salivary parameters that determine the stability of the enamel in the oral environment are pH, flow rate (SFR), oral clearance, concentrations of calcium, phosphate, and fluoride ions, and levels of oral microorganisms.[8] The optimal functions of saliva are proportionally maintained by the stability of its pH, buffering capacity, and flow rate.[9] In other words, alterations in any of these parameters may drastically alter the salivary functions, which may affect both oral and systemic health.[10,11]

In the present study, we aimed to assess the effect of consumption of different types of dates on the salivary pH among children in KSA.

Materials and Methods

This experimental study included 6–15-year-old Saudi Arabian children who were enrolled at the Department of Pediatric Dentistry and Orthodontics, King Khalid University College of Dentistry, Abha. The effect of the consumption of different varieties of date fruits on salivary pH values was examined. A convenient sample size of 15 children was selected for the study, and informed consent was obtained from all the parents/guardians. Children who were on medications, suffering from systemic illness or having active carious lesions, or those who had recently received topical fluoride therapy were excluded from the study. The study protocol was explained to the subjects in detail. The experiment was conducted over a period of 7 days. Five commonly consumed varieties of dates (Safree (صفري, Nabtat Seif (نبتة سيف), Khalas (خلاص), Sukkari (سكري), and Segae (صقعي) were used in this study. Grapefruit and cotton pellets were used as the positive and negative controls, respectively.

The study was conducted over a period of 7 days, with each child consuming one piece of a specific type of date fruit each day for 5 days; on the sixth and seventh day, each child was required to chew on a quarter of a grape fruit (positive control) and a sterilised cotton pellet (negative control), respectively. Salivary samples from unstimulated subjects were collected at least 1 h after breakfast; the salivary pH was recorded every day for 7 days. The subjects were instructed to rinse their mouth with plain water after having breakfast and not to have anything after breakfast till the sample collection was performed. Saliva from stimulated subjects was collected exactly 5 min after they consumed the designated date fruit/grapefruit or after they chewed on the cotton pellet for 1 min.

Collection of saliva samples

The subjects were seated comfortably on a chair with their heads bent forward, and were asked to spit into a sterile cup. Saliva was collected twice: before the consumption of the test date fruit and 5 min after eating the grapefruit. The salivary pH was directly estimated using a digital pH meter (HORIBA B-713 LAQUAtwin Compact pH Meter, Kyoto, Japan) and calibrated with buffers (pH 4 and 7). The use of this technique for measuring salivary pH has been reported previously.[12,13] The electrode was cleaned with a stream of distilled water and placed in a standard solution (pH 7) in between readings to ensure that the readings were stable. The readings were obtained by a well-calibrated recorder who was blinded to the study subjects; the saliva containers were coded to eliminate the possibility of observer's bias.

Statistical analysis

The values were entered into an MS excel sheet and statistically analysed using IBM SPSS statistics version 20.0 (SPSS, Chicago, IL, USA). Significant differences between the means were determined using paired t-test and one-way analysis of variance (ANOVA). Comparisons of mean differences among multiple groups before and after

salivary stimulation were performed by post hoc Tukey's HSD test. A p-value $< .05$ was considered statistically significant.

Results

The lowest mean salivary pH among the five date groups was recorded for Khalas (pH 6.26), followed by those for Safree (pH 6.31), Nabtat Seif (pH 6.36), Segae (pH 6.44), and Sukkari (pH 6.45) (Table 1). No significant difference in the pH scores of subjects from the different groups was found before salivary stimulation, whereas after 5 min of salivary stimulation, there was a significant difference in the pH scores of all five groups (Table 2). The highest mean difference was seen in case of Khalas (.47), followed by those in case of Sukkari (.45), Nabtat Saif (.44), Segae (.38), and Safree (.35) (Table 3). As expected, the lowest mean salivary pH (5.35) was recorded 5 min after consumption of the grape fruit, with a mean difference of 1.37; however, chewing the cotton pellets resulted in the maximum levels of salivary pH (6.9), with the minimum mean difference, compared to the values for other date-consuming groups.

Comparison of pH scores obtained 5 min after salivary stimulation in the different groups by the post hoc Tukey's HSD test revealed that the mean difference between the Safree- and grape fruit-consuming groups was 1.020, indicating that the reduction of pH scores in the grape fruit-consuming group was significantly higher than that in the Safree-consuming group. The mean difference between the Nabtat Seif- and grape fruit-consuming groups was .9333, whereas that between the Nabtat Seif-consuming and cotton pellet-chewing groups was .5133; this shows that the reduction of pH scores in the grape fruit-consuming group was significantly higher than that in the Nabtat-consuming group, and the reduction of pH scores in the Nabtat-consuming group was significantly higher than that in the cotton pellet-chewing group. The mean difference between the pH values of the Khalas- and grape fruit-consuming groups was .9000, and that between the Khalas-consuming and cotton pellet-chewing groups was .5447, indicating that the reduction of pH scores in the grape fruit-consuming group was significantly higher than that in the Khalas-consuming group, and the reduction of pH scores in the Khalas-consuming group was significantly higher than that in the cotton pellet-chewing group. The mean difference between the Sukkari- and grape

Table 1: Descriptive statistics of pH values before and after salivary stimulation in the different groups.

	Groups	Number of subjects (N)	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
Before salivary stimulation	Safree	15	6.67	.494	.127	6.39	6.94
	Nabtat Seif	15	6.80	.387	.100	6.59	7.01
	Khalas	15	6.73	.368	.095	6.53	6.94
	Sukkari	15	6.91	.209	.054	6.79	7.02
	Segae	15	6.82	.276	.071	6.67	6.97
	Grapefruit	15	6.72	.231	.060	6.59	6.85
	Cotton pellet	15	6.83	.234	.061	6.70	6.96
	Total	105	6.78	.328	.032	6.72	6.85
5 min after salivary stimulation	Safree	15	6.31	.441	.114	6.07	6.56
	Nabtat Seif	15	6.36	.400	.103	6.14	6.58
	Khalas	15	6.26	.348	.090	6.07	6.45
	Sukkari	15	6.45	.396	.102	6.23	6.67
	Segae	15	6.44	.427	.110	6.20	6.68
	Grapefruit	15	5.35	.541	.140	5.05	5.65
	Cotton pellet	15	6.90	.220	.057	6.78	7.02
	Total	105	6.30	.588	.057	6.18	6.41

Table 2: Comparison of the pH values before and 5 min after salivary stimulation among the different groups by one-way ANOVA.

ANOVA						
		Sum of Squares	df	Mean Square	F	P value
Before salivary stimulation	Between Groups	.582	6	.097	.898	.500[a]
	Within Groups	10.593	98	.108		
	Total	11.176	104			
5 min after salivary stimulation	Between Groups	19.758	6	3.293	19.946	.000[b]
	Within Groups	16.180	98	.165		
	Total	35.938	104			

[a] Statistically non-significant.
[b] statistically significant.

Table 3: Descriptive statistics of the differences between the pH values before and 5 min after salivary stimulation among the different groups.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Safree	15	.3533	.57305	.14796	.0360	.6707	-.40	1.40
Nabtat Seif	15	.4400	.54090	.13966	.1405	.7395	-.60	1.70
Khalas	15	.4733	.46363	.11971	.2166	.7301	-.40	1.40
Sukkari	15	.4533	.49116	.12682	.1813	.7253	-.70	1.30
Segae	15	.3800	.38582	.09962	.1663	.5937	-.20	1.00
Grapefruit	15	1.3733	.47879	.12362	1.1082	1.6385	.60	2.40
Cotton pellet	15	−.0733	.12228	.03157	−.1410	−.0056	-.30	.10
Totald	105	.4857	.60103	.05865	.3694	.6020	-.70	2.40

Table 4: Comparison of the mean differences in pH values before and 5 min after salivary stimulation among the different groups by Tukey's HSD test.

(I) GROUP	(J) GROUP	Mean Difference (I-J)	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
Safree vs	Nabtat Seif	−.08667	.16734	.999	−.5904	.4171
Safree vs	Khalas	−.12000	.16734	.991	−.6238	.3838
Safree vs	Sukkari	−.10000	.16734	.997	−.6038	.4038
Safree vs	Segae	−.02667	.16734	1.000	−.5304	.4771
Safree vs	Grapefruit	−1.02000[a]	.16734	.000	−1.5238	−.5162
Safree vs	Cotton pellet	.42667	.16734	.153	−.0771	.9304
Nabtat Seif vs	Khalas	−.03333	.16734	1.000	−.5371	.4704
Nabtat Seif vs	Sukkari	−.01333	.16734	1.000	−.5171	.4904
Nabtat Seif vs	Segae	.06000	.16734	1.000	−.4438	.5638
Nabtat Seif vs	Grapefruit	−.93333[a]	.16734	.000	−1.4371	−.4296
Nabtat Seif vs	Cotton pellet	.51333[a]	.16734	.043	.0096	1.0171
Khalas vs	Sukkari	.02000	.16734	1.000	−.4838	.5238
Khalas vs	Segae	.09333	.16734	.998	−.4104	.5971
Khalas vs	Grapefruit	−.90000[a]	.16734	.000	−1.4038	−.3962
Khalas vs	Cotton pellet	.54667[a]	.16734	.024	.0429	1.0504
Sukkari vs	Segae	.07333	.16734	.999	−.4304	.5771
Sukkari vs	Grapefruit	−.92000[a]	.16734	.000	−1.4238	−.4162
Sukkari vs	Cotton pellet	.52667[a]	.16734	.034	.0229	1.0304
Segae vs	Grapefruit	−.99333[a]	.16734	.000	−1.4971	−.4896
Segae vs	Cotton pellet	.45333	.16734	.107	−.0504	.9571
Grapefruit vs	Cotton pellet	1.44667[a]	.16734	.000	.9429	1.9504

[a] The mean difference is significant at the .05 level.

fruit-consuming groups was .9200, and that between the Sukkari-consuming and cotton pellet-chewing groups was .5267, showing that the reduction of pH scores in the grape fruit-consuming group was significantly higher than that in the Sukkari-consuming group, and the reduction of pH scores in the Sukkari-consuming group was significantly higher than that in the cotton pellet-chewing group. The mean difference between the Segae- and grape fruit-consuming groups was .9933, indicating that the reduction of pH scores in the grape fruit-consuming group was significantly higher than that in the Segae-consuming group. Furthermore, the mean difference between the cotton pellet-chewing and grape fruit-consuming groups was 1.467, showing that the reduction of pH scores in the grape fruit-consuming group was significantly higher than that in the cotton pellet-chewing group ($p < 0.05$; Table 4). Hence, the change in pH scores in the grapefruit-consuming group was significantly higher than that in the other groups.

Discussion

Various electrolytes such as sodium, potassium, calcium, magnesium, phosphates, and bicarbonates are present in the saliva. The other constituents thereof include immunoglobulins, enzymes, mucin, proteins, urea, and ammonia. Bicarbonates, phosphates, and urea maintain the pH and buffering capacity of saliva. Furthermore, salivary calcium, phosphates, and proteins are responsible for the maintenance of the balance between demineralisation and remineralisation in the enamel, whereas immunoglobulins, enzymes, and proteins are associated with the antibacterial action of saliva.[14] The viable range of pH in the salivary flow is between 5.3 (low flow) and 7.8 (high flow), with a resting value of approximately 6–7.[15]

The major components of dates are carbohydrates (70%), especially sugars. The sugars present in almost all types of dates are mostly invert sugars that get rapidly absorbed by the

human body.[16,17] Moreover, in addition to being good sources of potassium and calcium, dates are rich in dietary fibres.[2]

Over 450 varieties or cultivars of date palm are grown in the KSA, and account for a yield of more than 1 million metric tons of dates, which is equivalent to about 14% of the total global production of dates.[18] Dates are one of the major dietary products produced and consumed in KSA; therefore, this experimental study was conducted to determine the effect of the consumption of different varieties of this fruit on the salivary pH values.

Subjects who were free from any kind of systemic illness or olfactory problems or who were not under any medications were included in the study, because salivary secretion is dependent on various factors. It has been clearly mentioned in a previous research that a salivary centre with nuclei in the medulla controls the salivary secretion.[14] Three types of stimuli trigger the secretion of saliva: mechanical (chewing), gustatory (taste), and olfactory (smell, though a weak stimulus). Moreover, circadian factors, pain, systemic diseases, certain medications, and psychological factors also affect the salivary secretion.[19] Although all these factors cannot be controlled in any experimental study, we tried to control a few aspects in the present study, such as systemic diseases, time, and olfactory factors.

The salivary pH in subjects who consumed the various kinds of dates did not decrease below the critical pH value for saliva (5.5), thus establishing that dates do not exert a deleterious effect on oral health. Dried fruits need to be chewed for a longer period owing to their firm textures, which results in an enhancement of the salivary flow.[20] Moreover, saliva is also stimulated due to the organoleptic properties of dried fruits. The saliva is saturated with calcium and phosphate, and thus, it protects the enamel from demineralisation. The balance between demineralisation and remineralisation is the primary factor determining the overall clinical effects of diet on teeth over time.[2] Dates have a very short oral clearance time, and are only mildly adhesive and tacky; thus, they have no deleterious effects on teeth.[21] Even if the salivary pH would decrease initially after the consumption of dates, their short oral clearance time makes it possible for the pH to rise to normal (alkaline) levels; hence, the teeth are not exposed to an acidic pH for longer durations, and the demineralisation of the hard tissues of the teeth is prevented.

Carotenoids and phenolics are responsible for the antioxidant properties of dates.[22] Khalas has been reported to have the highest antioxidant activity compared to other types of dates such as Fard and Khasab.[23]

Contrary to our findings with the date fruits, the salivary pH was found to be below the critical value 5 min after grapefruit consumption. Similar findings have been reported in a previous study, in which the greatest decrease in salivary pH was noted after the consumption of grape juice, followed by those for orange and pineapple juice.[24] In another study conducted on animals, grape fruit juice was found to cause more demineralisation than plum, mango, or pineapple juice; in addition, fruit juices were reported to be 10 times more destructive to the teeth than the whole fruits.[25]

Acids produced by bacteria remain in the oral cavity for longer periods when the teeth are constantly exposed to sugary drinks, leading to dental erosion and development of caries. Reducing the intake of snacks and sugary juices may aid the prevention of tooth demineralisation. Salivary and plaque pH measurements have been considered as valid methods for assessing the deleterious effects of any kind of diet. The consumption of a low-pH drink reduces the pH of the resting plaque.[26] It is crucial to determine the duration until which this decrease in pH remains at its minimum, because when it reaches the "critical pH" value, enamel dissolution is initiated. The lower the pH, the faster is the initiation of demineralisation.[27]

The secondary outcomes of the present study show that the lowest mean salivary pH was recorded for Khalas (pH 6.26), followed those for Safree (pH 6.31), Nabtat Seif (pH 6.36), Segae (pH 6.44), and Sukkari (pH 6.45). When compared to the pH values before consumption of the dates, the highest difference in mean pH values was seen in case of Khalas (.47), followed by those in case of Sukkari (.45), Nabtat Saif (.44), Segae (.38), and Safree (.35). Grapefruit presented with the lowest mean salivary pH (pH 5.35) 5 min after its consumption; chewing the cotton pellets presented with the maximum increase in salivary pH.

One of the limitations of the current study is the small sample size. Moreover, the effect of caries activity on salivary pH was not examined in this study. The oral clearance time and stress level of subjects could not be assessed due to the time constraint. Nevertheless, to the best of our knowledge, this is the first study to evaluate the effects of different types of dates on the salivary pH in children from KSA.

Conclusion

Given the limitations of this study, it was concluded that consumption of date fruits is not deleterious to oral health, as they do not result in a reduction of the salivary pH below the critical value. Further large-scale studies are recommended to test the salivary pH levels at different time intervals and following the consumption of a combination of dates and other commonly consumed beverages.

Declaration of Helsinki

This study follows the guidelines of the Helsinki Declaration.

Source of funding

None.

Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

Ethical approval was obtained from the Scientific Research Ethics Committee (HA-06-B-001; REC #2016-6-23).

Authors' contributions

SBA was responsible for the data acquisition, drafting, and final approval of this article; RAT contributed towards

the study concept, and was responsible for the design, revision, and final approval of this article; GKB was responsible for the data acquisition, interpretation of collected data, literature review, and the final approval of this article; AD was responsible for the critical evaluation of this paper, data analysis, and the final approval of this article; EAA was responsible for the data acquisition, data interpretation, and the final revision of this article; GZM assisted with the data analysis, literature review, and the final approval of this article; ZMA was responsible for the critical evaluation of the initial draft of this article, and the revision and final approval of this article. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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