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Fluoride concentration and erosive potential of Brazilian concentrated natural fruit juices

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Abstract

Objective: To estimate the erosive potential of fruit juices consumed by a group of Brazilian children.

Methods: The study was carried out in two phases: Different fruit types were selected based on a dietary questionnaire applied to a random group of 40 patients' mothers attending public pediatric services; the thirteen most cited fruits (acerola, orange, passion fruit, mango, cashew apple, grape, guava, soursop, pineapple, apple, lemon, tangerine and papaya) were purchased at local markets of João Pessoa, Northeast region of Brazil. The concentrated juices were prepared using a processor. The material was centrifuged for pH and fluoride measurements (in duplicate) using a pH electrode and an ion sensitive electrode, respectively. Comparisons of mean±SD were done by ANOVA and Schefé test.

Results: Acerola was the most cited fruit (n=24). The pH of the fruit juices varied from 2.21 (lemon) up to 5.52 (papaya) ($p<0.01$). Only papaya juice showed pH above 5.5. Fluoride concentrations varied from 0.04 (mango) up to 0.42 mg/L (lemon) ($p>0.01$).

Conclusions: The fluoride concentration was low for all fruits juices evaluated. Except for papaya, the majority of the concentrated fruits juices presented critical pH values indicating some erosive potential.

Key words: Dental enamel; diet; fruit; fluoride; pH; tooth erosion.

Concentração de flúor e potencial erosivo de sucos de frutas naturais concentrados

Resumo

Objetivo: Estimar o potencial erosivo de sucos de frutas consumidos por crianças brasileiras.

Métodos: O estudo foi conduzido em duas fases: diferentes tipos de frutas foram selecionados baseados em questionário de dieta aplicado em grupo randomizado de 40 mães de pacientes atendidos no serviço público de Pediatria; as 13 frutas mais citadas (acerola, laranja, maracujá, manga, caju, uva, gioaba, graviola, abacaxi, maça, limão, tangerina e mamão) foram adquiridas em supermercados de João Pessoa, Brasil. Os sucos concentrados foram preparados usando processador. O material foi centrifugado para mensuração do pH e concentração de flúor (duplicata) usando eletrodo de pH e de íon seletivo de flúor, respectivamente. Comparação de médias ± desvio-padrão foi feita por ANOVA e teste de Scheffé.

Resultados: Acerola foi a fruta mais citada (n=24). O pH dos sucos de frutas variou de 2,21 (limão) a 5,52 (mamão) ($p<0,01$). Apenas o suco de mamão apresentou pH acima de 5,5. A concentração de flúor variou de 0,04 (manga) a 0,42 mg/L (limão) ($p>0,01$).

Conclusões: A concentração de flúor foi baixa para todos os sucos avaliados. Exceto para mamão, a maioria dos sucos de frutas concentrados apresentou valor de pH crítico, indicando algum potencial erosivo.

Palavras-chave: Esmalte dental; dieta; fruta; flúor; concentração de íons hidrogênio; erosão dentária.

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Introduction

Fruit juice helps children to fulfill the recommendation to eat more fruits and vegetables and its consumption accounts for 50% of all fruit servings consumed by children [1]. In the last decades, fruit juice consumption by preschoolers has increased in many countries including Brazil [1-3]. Although fruit juices have known nutritional beneficial aspects, they may also be detrimental [4]. Regarding oral health, caries and dental erosion have already been linked to fruit juice consumption in many circumstances [5,6].

Dental erosion is an irreversible lesion of the dental structure that is not related to microbial chemical components [7]. The lesion reflects mineral loss of the tooth and is formed when the oral environment reaches pH below pH 4.5, a value that is below the critical pH for hydroxyapatite (critical pH 5.5) and fluorapatite (critical pH 4.5). The etiological agents for dental erosion can be extrinsic such as diet and oral medicines; or intrinsic such as salivary flow problems and gastroesophageal reflux disease [8]. Drinks and foods are important extrinsic factors [6,9].

Apart from differences in scoring systems, there are enough evidences of an increasing prevalence of dental erosion in children [10,11]. Among Brazilian children, a low prevalence was observed in the South region. However, this might not be the true value for other parts of the country where a high consumption of soft drinks or fruit juices is taking place [12,13]. Many tropical fruits are produced in the Northeast region of Brazil due to its favorable climate condition. A great deal of the fruit production is consumed in local markets as processed material and part of the production is exported to Europe and Latin American countries. The estimates of fruit juice consumption in the Northeast region of Brazil have increased remarkably in the last years after decades of low consumption [14]. It has been also observed that concentrate fruit juices commercialized in glass bottles are becoming widely used by Brazilian families [2]. These data provides a strong indication that a higher consumption of acidic drinks among children will occur in the near future. Since natural or bottled fruit juice consumption is increasing among children, the erosive potential of tropical fruits juices is warranted to be evaluated. Thus, the aim of this study was to estimate the erosive potential of frequently consumed fruit juices consumed by a group of Brazilian children.

Methods

Diet questionnaire

Forty parents or tutors of children assisted at the Clinics of Cariology and Pediatric Dentistry at the Federal University of Paraíba were invited to participate in the study. From May until August 2008 the parents were interviewed to qualitatively and quantitatively determine the mostly ingested fruit juices by children by answering a questionnaire. They indicated 13 flavors of natural fruit juices. The list of the most consumed fruit juices were: acerola, orange, passion fruit, mango, cashew apple, grape, guava, soursop, pineapple, lemon, tangerine, apple and papaya (Table 1).

pH and fluoride measurements

The fruits were bought at local markets in João Pessoa, Brazil and identified. On the same day, the fruit juice was obtained and submitted to pH and fluoride measurements. The concentrated natural juices were prepared as from ripe fruit specimens, using a processor (Black and Decker, Uberaba MG, Brazil) for 5 min. In order to obtain the supernatant the samples were centrifuged at 19 ºC and 5,100 rpm for 10 min.

The pH measurement of the supernatant was carry out directly by means of a pH electrode (model 91-02 Orion Research Corp. Cambridge Mass, USA) coupled to a potentiometer (model Orion 290 A+, Orion Research Corp., Cambridge, Mass, USA). Due to high viscosity, pH values of mango and guava juices were determined by indicative universal strip (Universalindikator pH 0-14, Merck, Darmstadt, Germany).

The analyses were carried out in triplicate, after calibration in two standard solution points (4.01 and 7.00) and after a slope above 95 %. Fluoride concentrations were determined using a fluoride-specific electrode (Orion, model 94-09, Orion Research Corp., Cambridge, Mass., USA) coupled to a potentiometer (Orion 290 A+, Orion Research Corp., Cambridge, Mass., USA). The Orion fluoride standard solutions 6.4, 3.2, 1.6, 0.8, 0.4 and 0.2 mg/L F were used to calibrate the measuring instrument. The samples of juices were buffered with TISAB II (Total Ionic Strength Adjustment Buffer). All pH and F measurements were performed in duplicate after frequent calibrations ($r > 0.95$).

Statistical analysis

Data was handled in SPSS statistical package, version 14.0. Comparisons between mean±SD were carried out by ANOVA and Post Test (Scheffé). Probability was previously set in 5%.

Ethical consent

The ethical committee of Health Science Center of the Federal University of Paraíba, Brazil, granted permission for the study.

Results

Table 1 shows (in ascending order) the pH values in the 13 fruit juices. Acerola, orange and passion fruit juices were the most consumed by children. The pH range was 2.21 up to 5.52. Papaya juice was the only one to show mean pH value above 5.5. The pH of lemon juice was statistically different from all other juices.

The fluoride concentration in the fruit juices varied from 0.04 up to 0.42 mg/L F (Table 1). No statistical difference was observed between fluoride concentrations of the tested fruit juices. For most juices (36.15%) the fluoride concentrations ranged from 0.04 to 0.08 mg/L F. In few samples the fluoride concentrations were above 0.20 mg/L F, but these values were not significantly different (p>0.05).

A correlation between pH data and fluoride concentrations in the juices was not observed (r=-0.51; p>0.05).

Table 1. Mean±SD pH and fluoride concentrations of natural fruit juices.

Fruit juices	n *	pH±SD**	Fluoride±SD (mg/ L)**
Lemon	2	2.21±0.020^{a}	0.42±0.045^{a}
Grape	7	2.92±0.070^{b}	0.08±0.001^{a}
Passion fruit	14	3.00±0.020^{b}	0.12±0.012^{a}
Acerola	24	3.34±0.005^{bc}	0.08±0.018^{a}
Tangerine	1	3.59±0.004^{bc}	0.38±0.390^{a}
Apple	1	3.86±0.007^{cd}	0.20±0.182^{a}
Orange	17	3.89±0.002^{cd}	0.25±0.030^{a}
Pineapple	3	3.94±0.020^{cd}	0.10±0.013^{a}
Graviola	4	3.96±0.000^{cd}	0.05±0.000^{a}
Guava	6	4.50±0.000^{de}	0.08±0.000^{a}
Mango	8	5.00±0.000^{ef}	0.04±0.000^{a}
Cashew	8	5.18±0.582^{f}	0.13±0.049^{a}
Papaya	1	5.50±0.000^{f}	0.07±0.01^{a}

* n = number of times the fruit was reported.
** ANOVA and Test of Scheffé (p<0.01).

Discussion

Except for grape and apple, all juices cited by the parents or tutors of the children are typical of the Northeastern region of Brazil. Apple and grapes were probably less consumed due to price and availability. In addition, the period of the year of the study has to be considered. Acerola, the most cited fruit (n=24) is virtually present during all the year, but some tropical fruits are seasonal dependent such as mango, cashew apple and pineapple [2]. These later fruits are more available in December, January and February.

In our study, pH variation of the fruit due to maturation was not evaluated. Maturation and seasonal conditions can reduce pH values [2]. In our study, lemon juice was the most acidic with pH value lower than coke-based drinks. A previous report confirms this number [15]. The pH values for orange and apple juices in our study were similar to other publications [15,16]. Orange, pineapple, mango, apple and guava juices showed pH values below the critical pH for fluorapatite (Table 1). It was observed that beverages with a pH higher than 4.2 resulted in minimal enamel erosion whereas erosion lesions were more evident for beverages with pH below 4.0 [17]. Considering these figures, in our study, guava, mango, cashew apple and papaya would be fruits with low erosive potential.

New foods are introduced to the children during weaning. Among these, it has been reported a higher consumption of fruits/fruit juices that can be related to erosive lesions [18]. A relationship between the prevalence of dental erosion and consumption of citric fruit juices was suggested in low income families [5]. The consumption of fruit juices starts off by weaning time, matching the time of the deciduous teeth eruption. Therefore our study focused in children due to the vulnerability for erosion in deciduous teeth [19,20].

The erosive potential of a substance can be related with the pH variables such as acid concentration, titration, acid type (phosphoric, maleic or citric acid), and general ionic driving forces in a solution. It cannot be neglected that under *in vivo* conditions, the presence of saliva buffers and ions (e.g. fluoride), acquired pellicle, dental biofilm are also important [8,15,21]. It must be pointed out that due to the logarithmic nature of the pH curve, the acid-base transitions can be extremely sharp and fast. It was already observed that the maximum drop in pH (below 5.5) after drinking fruit juices occurs within 5 minutes [4]. In our study, the focus was the pH data complemented with fluoride concentrations. Larsen and Nyvad [17] reported that the extent of erosion lesions was not associated with titratable acidity since dissolution of enamel increased logarithmically inversely with the pH of the beverages tested. Even though most of these observations are *in vitro* data, the challenge of a low pH in the oral mouth can be estimated [21].

The measurements were done immediately after the juice preparation in order to avoid any changes in H^{+} ions due to degradation of the juice. However, the erosive potential of these fruits should be interpreted with caution because individual factors and cultural habits for fruit consumption may vary among subjects. For instance, oral frequency and preparations may differ among the families and their children [13]. In addition, salivary protective factors may vary from child to child. In any case, the low pH of these fruit juices is an indication that parents and professionals should be aware about the potential erosive effect of some fruits.

Fluoride concentrations in grape, acerola, soursop, guava, mango and papaya juices were similar to physiologic fluoride concentration in saliva (0.02 up to 0.05 mg/L), in the dental plaque (0.03 mg/L) and in the plaque fluid (0.01 up to 0.02 mg/L) [22,23]. Hence, any additional protective effect as regarded to juices fluoride concentrations seems unlikely [24].

When compared to caries, dental erosion has the particular feature of having a dental surface unable to get re-established due to the destruction of the enamel crystals [9,24]. Therefore, calcium can be of importance for enamel protection. It has been suggested that fruit juices that are enriched with calcium can prevented enamel erosion and decreased root surface erosion [25]. However, natural calcium concentrations and availability in fruit juices are rather low compared to the 100 mg/L tested. For some of the fruits selected in our study the reported number are as follows: 7.2 mg/100 g (acerola), 5.3 mg/100 g (mango), 4.1 mg/100 g (passion fruit), 3.6 mg/100 g (guava), and 0.7 mg/100 g (cashew apple) [2]. For bottled fruit juices the fortified calcium juices can be an option. However, this is not valid for home-made natural tropical fruit juices.

In summary, the low pH and fluoride concentration of the fruit juices analyzed in this study seems to be important due to their erosive potential. Certainly, differences in the daily frequency consumption in young children have to be considered before considering the fruit juice as a risk for dental erosion. It also must be pointed out about the beneficial aspects of fruits being a good source of vitamin C and other nutrients.

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