

# FLUORIDE CONCENTRATIONS IN INDUSTRIALIZED BEVERAGES CONSUMED BY CHILDREN IN THE CITY OF BAURU, BRAZIL

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## ABSTRACT

The increasing consumption of juices, soft drinks and teas among children has increased significantly fluoride ingestion at the age range of risk for development of dental fluorosis. Objective: The purpose of this study was to evaluate fluoride concentrations in some brands of industrialized beverages consumed by children in the city of Bauru, SP, Brazil. Material and Methods: 98 brands of beverages were analyzed, divided into 3 lots, comprising 36, 32 and 30 brands, respectively, for the first, second and third lots. Fluoride concentrations were determined by HMDS-facilitated diffusion, using a fluoride ion-specific electrode (Orion 9409). Results: Fluoride concentrations ranged between 0.04 and 1.76 µg F/mL. It was observed a wide variation in fluoride concentrations among the different brands, as well as the different lots of the same brand. There was no information on fluoride concentrations on the labels of any product. Conclusions: Some of the products analyzed could contribute significantly to the total fluoride intake and, thus, be important risk factors for development of dental fluorosis, which indicates the need of controlling the production of these beverages with respect to fluoride concentration.

**Uniterms:** Fluoride; Dental fluorosis; Beverages; Children.

## INTRODUCTION

Fluoride has been shown to be an effective agent for the control of dental caries over more than five decades. Since 1970, this ion has become increasingly available for populations with and without fluoridated drinking water, in a wide range of vehicles such as dentifrices, mouthrinses, supplements, infant formulas and industrialized beverages, besides to dental products for exclusive professional application<sup>2,3,5,7,9,13,15,16,18</sup>. In Brazil, fluoridation of dentifrices started in 1980 and these products became an important source of fluoride exposure and ingestion<sup>15,19</sup>.

The exposure to fluoride from the multiple available sources resulted in a significant improvement in the oral health status of population. Simultaneously, however, this led to an increase in the prevalence of dental fluorosis, mainly in its mild and very mild forms, even in regions not supplied with fluoridated water<sup>2,13,16,18</sup>. Water has been considered responsible for this increase in 40% of cases. The remaining 60% is attributed to other fluoride sources<sup>14</sup>.

Dental fluorosis results from the excessive ingestion of fluoride during the period of enamel formation and its severity is directly related to the absorbed dose of this ion, in addition to the influence of environmental factors. The clinical appearance of mild dental fluorosis is characterized by bilateral, diffuse opaque, white striations that run horizontally across the enamel. In the more severe forms, the enamel may become discolored and/or pitted<sup>2,22</sup>.

Significant changes have occurred with respect to children's feeding habits in the last decades, with increasing consumption of industrially processed foods and beverages<sup>4,7-9,11,15</sup>. A study published in 1997 reported that 56% of the United States population was directly exposed to fluoridated water, but this estimate can be even greater if indirect exposure from foods and beverages produced using fluoridated water is also considered<sup>11</sup>. Therefore, the impact of fluoridated water is higher when it is used for the processing of foods and beverages<sup>2,4,8,9,11</sup>.

There are several reports addressing the assessment of fluoride concentrations in foods and beverages consumed

by children at the age risk for development of dental fluorosis<sup>4-10,12,20</sup>. Most of these studies have shown that the fluoride concentration in some products could increase the prevalence of dental fluorosis, if consumed on a regular basis. However, there is no study evaluating fluoride levels in beverages especially produced for children consumption in Brazil, i.e., with packages having sizes and labels directed to these consumers. In addition, most beverages typically consumed by children in Brazil do not present information on fluoride concentration on their labels. Therefore, the purpose of this study was to evaluate fluoride concentrations in some brands of industrialized beverages specifically produced for children consumption.

## MATERIAL AND METHODS

### Sample selection

Beverages were purchased in supermarkets at the city of Bauru, São Paulo State, Brazil. Products with packages and labels specifically designed for children were chosen in an attempt to represent the most consumed beverages by this population. Products included fruit and soy-based juices, black teas, soft drinks and coconut water. In addition, the beverages were purchased in three different dates, in order to address possible variations among lots of the same product. For lots 1, 2 and 3, respectively, a total of 36, 32 and 30 products were acquired, totalizing 98 beverages. All brands and products were coded.

### Fluoride analysis

The products were opened on the day of the analysis. Fluoride concentrations were determined after overnight hexamethyldisiloxane (HMDS)-facilitated diffusion<sup>21</sup> as modified by Whitford<sup>23</sup> (1996), using a fluoride ion-specific electrode and a miniature calomel reference electrode (Accumet, no. 13-620-79; Fischer Scientific, Pittsburgh, PN, USA), coupled to a potentiometer (model EA 940; Orion Research Inc., Cambridge, MA, USA). During the diffusion process, which was conducted at room temperature, the solutions in the nonwetable Petri dishes (Falcon, No. 1007; Becton Dickinson, Franklin Lakes, NJ, USA) were gently swirled on a rotary shaker. Fluoride standards (10, 50, 100 and 250 nM F) were prepared by serial dilution of a stock-standard containing 0.1 M of fluoride (Orion 940906) in triplicate and diffused in the same manner as the samples. Comparison with identical nondiffused fluoride standards showed that recovery after diffusion was > 99%. The standard curve had a correlation coefficient  $\geq 0.99$ . All samples were analyzed in duplicate. The mean repeatability of the fluoride readings, based on the duplicate samples, was 94.9%.

## RESULTS

Fluoride concentrations in the different brands and flavors of beverages analyzed in this study are given on

Table 1. Fluoride concentrations in the first lot ranged between 0.051  $\mu\text{g F/mL}$  (sample 18) and 0.868  $\mu\text{g F/mL}$  (sample 30). In the second and third lots, respectively, fluoride concentrations ranged from 0.047  $\mu\text{g F/mL}$  (sample 18) to 1.451  $\mu\text{g F/mL}$  (sample 30), and from 0.040  $\mu\text{g F/mL}$  (sample 34) to 0.762  $\mu\text{g F/mL}$  (sample 31).

The juices (including soy-based products) and coconut water presented relatively low fluoride concentrations, varying between 0.040  $\mu\text{g F/mL}$  (sample 34, lot 3) and 0.300  $\mu\text{g F/mL}$  (sample 21, lot 2). With respect to black tea samples, higher fluoride concentrations were detected, ranging from 0.462  $\mu\text{g F/mL}$  (sample 27, lot 1) to 1.762  $\mu\text{g F/mL}$  (sample 31, lot 3).

## DISCUSSION

Foods, beverages, drinking water and dental products are considered as the main sources of fluoride intake for children above 1 year of age<sup>2,4,7-9,15,16,18</sup>. Most foods have fluoride concentrations lower than 0.5  $\mu\text{g F/g}$ , except for seafood and chicken products, which may present higher fluoride levels due to the inclusion of bone, skin and shells during processing<sup>13</sup>.

Fluoride concentrations in beverages result from the concentration of this ion in the water used during industrial processing. These concentrations usually range between 0.1 and 1.4  $\mu\text{g F/mL}$ , except for teas, which may have up to 7  $\mu\text{g F/mL}$ <sup>4,7-10,12,17,20,24</sup>. Most beverages analyzed in the present study showed fluoride concentrations below 0.1  $\mu\text{g F/g}$ . For teas, fluoride levels varied between 0.6 and 1.7  $\mu\text{g F/mL}$ . Considering that the recommended dose of fluoride intake varies between 0.05 and 0.07 mg F/ Kg body weight, the teas analyzed in this study can contribute significantly for the total fluoride intake, which therefore increases the risk for development of dental fluorosis. In this sense, the consumption of 200 mL of a tea containing 1.76  $\mu\text{g F/mL}$  accounts for about 0.03 mg F/ Kg body weight for a child weighing 12 Kg (approximately 2 years old). It is worth emphasizing that this dose (0.03 mg F/ kg) would be reached with the ingestion of only this beverage, not including other foods and beverages consumed during the day. Several reports have demonstrated high fluoride concentrations in foods typically consumed by children, such as powdered milk, ready-to-drink chocolate milks, cereals and snacks<sup>1,4,6,8,9</sup>. Moreover, the early use of fluoridated dentifrices by children is of concern, mainly due to the inverse relationship between fluoride ingestion from this source and the child's age. Fluoride dentifrices can account up to 80% of total daily fluoride intake by 2-3 year-old children<sup>1</sup>.

The variation in fluoride concentrations among the lots is another issue that deserves attention. In the present study, significant variations were observed for most analyzed products and differences of 200-300% in lots of the same products were detected (Table 1 – beverages 16, 17, 29, 31-34 and 36). For beverages with low fluoride concentrations, these variations may have little impact on total fluoride intake, as for beverages 16, 17, 34 and 36. For products with

high fluoride levels, however, such variations can contribute significantly for the total intake of this ion (beverages 29-32). These findings suggest the need of a more effective control in the production and labeling of the evaluated products by the surveillance authorities, as none of them presented this information on their labels.

Although the increase in the prevalence of dental fluorosis verified in the last decades has occurred mainly in the mildest forms, thus not affecting dental function and, many times, not compromising esthetics, this indicates the need for controlling fluoride intake, especially in children below 6 years of age. This control must be based on the

correct indication of fluoride use by dental professionals and instructions given to general population concerning the main sources of fluoride intake, in order to make possible the rational use of this non-invasive caries control approach. Furthermore, sanitary surveillance actions must be more effectively reinforced, by means of a systematic analysis, in order to regulate and establish as mandatory the presentation of fluoride concentration on the labels of foods and beverages.

**TABLE 1-** Fluoride concentration ( $\mu\text{g/mL}$ ) in the different brands and flavors of beverages (tree lots each) consumed by children, Brazil, 2005

Beverage	Sample codes	Flavor	Lot 1	Lot 2	Lot 3	Mean	SD
Soy-based juices (brand A)	1	Apple	0.079	0.139	0.093	0.103	0.031
	2	Pineapple	0.105	0.112	0.110	0.109	0.003
	3	Orange + Papaya	0.082	0.139	0.097	0.106	0.029
	4	Passion fruit	0.102	0.103	0.135	0.113	0.018
Soy-based juices (brand B)	5	Orange	0.112	0.147	0.104	0.121	0.022
	6	Original	0.128	0.143	0.145	0.138	0.009
	7	Pear	0.186	—	—	—	—
	8	Apple	0.133	0.168	0.160	0.153	0.018
	9	Grape	0.170	0.213	0.215	0.199	0.025
Soy-based juices (brand C)	10	Pineapple	0.069	0.070	0.076	0.071	0.003
	11	Apple	0.060	0.078	0.108	0.082	0.024
	12	Orange	0.073	0.064	0.059	0.065	0.007
	13	Grape	0.076	0.103	0.082	0.087	0.014
Soy-based juices (brand D)	14	Orange	0.091	0.162	0.113	0.122	0.036
	15	Peach	0.107	0.201	—	0.154	0.066
	16	Apple	0.070	0.194	0.117	0.127	0.062
	17	Pear	0.069	0.202	—	0.135	0.094
Coconut water (brand E)	18	Coconut water	0.051	0.047	0.059	0.052	0.006
Juices (brand F)	19	Strawberry	0.252	0.293	0.198	0.247	0.047
	20	Passion fruit	0.118	0.155	0.189	0.154	0.035
	21	Grape	0.206	0.300	0.201	0.235	0.055
Juices (brand G)	22	Strawberry	0.077	0.098	0.112	0.095	0.017
	23	Passion fruit	0.090	0.141	0.107	0.112	0.025
	24	Grape	0.081	0.137	0.149	0.122	0.036
	25	Pineapple	0.083	0.111	0.140	0.111	0.028
Black teas (brand H)	26	Lemon	0.588	—	—	—	—
	27	Red fruits	0.462	—	—	—	—
	28	Peach	0.606	—	—	—	—
Black teas (brand I)	29	Passion fruit	0.635	1.236	0.719	0.863	0.325
	30	Tangerine	0.868	1.451	1.741	1.353	0.444
	31	Lemon	0.835	0.657	1.762	1.084	0.593
	32	Peach	0.691	0.876	1.706	1.091	0.540
Soft drinks (brand J)	33	Cola	0.105	0.060	0.111	0.092	0.027
	34	Guarana	0.102	0.076	0.040	0.072	0.031
	35	Orange	0.105	0.121	0.111	0.112	0.008
	36	Lemon	0.100	0.052	0.130	0.094	0.039

## CONCLUSIONS

The results of the present study suggest the need of controlling the production of the foods and beverages with respect to fluoride concentration. Specific standardization of the product labels is also needed, by obligating manufacturers to present clear information about fluoride concentration in the products because the widespread consumption of certain beverages along with other sources of fluoride intake could lead to an increase in the prevalence of dental fluorosis.

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