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Fluoride content of bottled water commercialized in two cities of northeastern Brazil

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Abstract

Aim: The objectives of this study were to evaluate the fluoride content of bottled water commercialized in two cities of northeastern Brazil and to compare the fluoride values measured in the water to the ones printed on the bottle label, considering risks (dental fluorosis) and benefits (caries control) of systemic fluoride exposure. **Methods:** Fifty-six water samples were collected from 20 brands available in several supermarkets with high turnover in different regions of the municipalities of São Luís (State of Maranhão) and João Pessoa (State of Paraíba) in 2009. Fluoride concentrations were determined by triplicate analysis using an ion-specific electrode. **Results:** The measured mean fluoride content varied from 0.001 to 0.270 ppmF with a mean (±SD) of 0.037 (±0.041) for the 56 samples. The majority of samples were found to contain less than 0.043 ppmF (92%). **Conclusion:** These results emphasize the importance of controlling the fluoride levels in bottled water enforced by the Brazilian Sanitary Surveillance Agency. Concerning the risks and benefits, fluoride concentrations in the evaluated bottled water samples were below the suggested concentration (0.7 mg F/l), having neither preventive effect nor the potential for causing dental fluorosis.

Keywords: fluoride, bottled water, product labeling, health surveillance

Introduction

The replacement of public water with bottled water for daily intake has been observed as a common trend among consumers in several countries[1-7]. In Brazil, between 1974 and 2003 there was an increase of 5.694% in the consumption of bottled water. The southeastern region of the country is responsible for 56.4% of the production of bottled water followed by the northeastern region, holding 23.2% of the national production[8].

According to data from the National Department of Mineral Production (DNPM) there was a total investment of R$ 44,644,273 in bottled water in the year of 2005 in Brazil[8]. Such an investment reflects the growing interest of consumers who use bottled water as their primary source of drinking water. Reasons for this preference include concern about the purity of public tap water, avoidance of chemicals such as chlorine, taste preferences and convenience[4,5,9-11].

Water fluoridation is a community health measure that is recognized worldwide for its role in preventing dental caries[12]. Therefore, attention must be given not only to public drinking water, but also to bottled water, since nowadays bottled water is no longer regarded as a privilege, being widely consumed by people who have a healthier lifestyle as a priority[7].

Some studies have shown several top selling brands containing a fluoride content above the recommended level, contributing to an increase in the incidence of dental fluorosis[3,6,13-14]. On the other hand, some products may have low fluoride content in their composition. Consequently, if these bottled waters are used as the primary source of drinking and cooking water, they might not be providing a preventive measure for dental caries[5,7,9].

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In the northeastern region of Brazil, temperatures can range from 28 to 35ºC and higher consumption of water is observed. Studies have revealed an increasingly greater incidence of dental fluorosis in this region[13,15], which highlights the need for strict regulation and rigorous surveillance of the fluoride content in bottled water for the region.

Evidence of fluoride concentration in bottled water consumed in the northeastern region of Brazil is scarce. Hence, this study aimed at analyzing the concentration of fluoride in bottled waters commercialized in the cities of São Luís, capital of the state of Maranhão (MA), and João Pessoa, capital of the state of Paraíba (PB), comparing the obtained values to the information given on the bottle labels, considering risks (dental fluorosis) and benefits (caries control) of systemic fluoride exposure.

Material and methods

Several brands of bottled water were purchased from supermarkets in the cities of João Pessoa (PB) and São Luís (MA). Whenever possible, 3 bottles of each brand, each with a different batch number and date of bottling, were purchased. All brands available on the market at the moment of purchase were analyzed for this research, except for brands of carbonated water. All samples were stored in 15 mL plastic vials at 10°C in the refrigerator until the moment of analysis. They were assigned an Arabic number as a code so that those undertaking the analysis would be blind to the source.

A fluoride-ion-specific electrode (Model 9409 BN, Orion, Cambridge, MA, USA) and a potentiometer (Model 720A, Orion) were used for fluoride measurements. Before starting the analysis, a calibration curve was made using known standard samples containing between 0.05 and 1.60 mg/L of fluoride, which were also used to construct standard curves. Both standard solutions and water samples were prepared by mixing 1.0 ml of each sample to 1.0 mL of Total Ionic Strength Adjusting Buffer II (TISAB II), a substance used to adjust the total ionic strength and the pH of the sample. All samples, including the standard solutions, were mixed using a vortex and kept at room temperature (25ºC) at the moment of reading.

The calibration was repeated after every ten-sample reading. Finally, millivolt readings were converted to fluoride ion concentration using the standard correlation curve. The reading was compared to the fluoride standard curve (r^2>0.99).

The data was entered into an Excel spreadsheet (Microsoft Excel®) where mean and standard deviations were calculated. The correlation curve was used, as well as the correlation coefficient ($r^2 \geq 0.999$). The data were statistically analyzed using a one-way ANOVA with a Tukey's post-hoc multiple comparisons test.

Results

Fifty-six water samples from twenty brands were analyzed. Thirty-two of those were purchased in João Pessoa and 24 were bought in São Luís between December 2008 and January 2009.

The label fluoride content (when given), the measured mean fluoride content (±SD) and the minimum and maximum values are shown in Table 1. The measured mean fluoride content varied from 0.001 to 0.270 mg F/L with a mean (±SD) of 0.037 (±0.041) for the fifty-six samples. The majority of samples were found to contain less than 0.043 mg F/L (92%) (Table 1, Figure 1).

Regarding the quality of the labeling of bottled waters, seventeen (85%) of the twenty brands surveyed showed the fluoride content on the labels. Upon analysis, ten brands (50%) of bottled water presented fluoride content higher than the value displayed on the label, whereas 4 (20%) brands showed a value lower than the one displayed on the label. Three (15%) of the 20 brands did not exhibit any fluoride content on their labels. Nevertheless, upon analysis, these brands were found

Table 1. Local of water fountains, labeled fluoride content, minimum fluoride concentration, maximum fluoride concentration and average fluoride content found on analysis.

Code	Fluoride label information (ppm)	Fluoride concentration (Mean± SD)	Minimum (ppm)	Maximum (ppm)
JP1	0.02	0.04 ± 0.002	0.029	0.042
JP2	NI*	0.01 ± 0.007	0.001	0.012
JP3	0.02	0.03 ± 0.001	0.023	0.041
JP4	0.04	0.02 ± 0.001	0.021	0.036
JP5	0.02	0.01 ± 0.001	0.011	0.017
JP6	0.02	0.03 ± 0.004	0.025	0.030
JP7	0.05	0.04 ± 0.002	0.036	0.040
JP8	0.21	0.23 ± 0.005	0.180	0.270
JP9	0.05	0.06 ± 0.001	0.059	0.080
JP10	0.01	0.03 ± 0.001	0.024	0.027
JP11	NI*	0.01 ± 0.001	0.010	0.016
SL1	0.01	0.03 ± 0.005	0.022	0.031
SL2	0.03	0.04 ± 0.010	0.033	0.053
SL3	0.01	0.01 ± 0.000	0.011	0.020
SL4	0.02	0.02 ± 0.005	0.010	0.024
SL5	0.03	0.04 ± 0.002	0.035	0.043
SL6	0.02	0.02 ± 0.003	0.010	0.022
SL7	0.05	0.04 ± 0.000	0.035	0.039
SL8	NI*	0.02 ± 0.008	0.021	0.036
SL9	0.01	0.02 ± 0.001	0.014	0.016

* Not informed

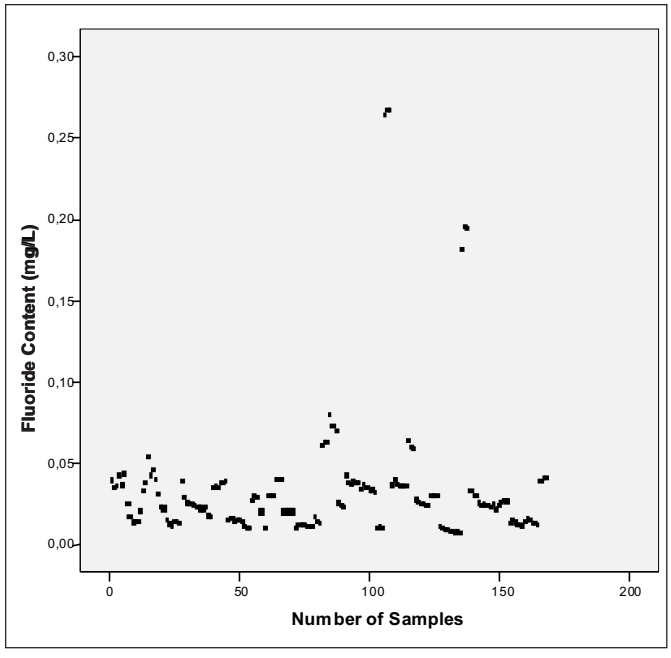

Fig. 1. Variation of fluoride content (mg/L) in the bottled water brands commercialized in João Pessoa - PB and São Luís - MA.

to have a small amount of fluoride content (ranging from 0.006 to 0.025). Only 3 brands (15%) presented concordance between the fluoride content measured and that shown on the product label (Table 1).

Of all the brands studied in this research, 85% were commercialized as fluoridated, even though they presented a fluoride content varying from 0.010 to 0.074 ppm F.

Discussion

The majority of the world's population is replacing public water with bottled water for the daily water intake. According to data from the DNPM, during the last thirty years there has been an increase in the consumption of bottled water, from 0.3 kg to 18.5 kg per capita per year. A comparable increase has also been observed in other countries[8]. There is a belief by the population that bottled water is healthier than tap water and free of impurities. This may be leading to the increase in the consumption of bottled water as opposed to public tap water[4].

Children who have bottled water as the primary source of drinking water may have its oral health affected in three ways: (1) they could be getting the appropriate amount of fluoride content, (2) they could be getting an amount of fluoride content below that necessary for dental caries prevention, or (3) they could be getting a dose above the recommended level, leading to the risk of developing dental fluorosis[1,16].

Bottled water brands commercialized in João Pessoa and São Luís analyzed in this research presented fluoride content below the limit recommended to have a preventive effect on dental caries. Note that, only public water in São Luís is artificially fluoridated.

Even if bottled water consumers are not using public water as their primary source of drinking water, they end up using the tap water for cooking and for the reconstitution of aliments. This leads to an additional intake of fluoride. Therefore, the population of João Pessoa may not be getting enough fluoride from the consumption of water as neither the public water nor the bottled water have enough fluoride content to prevent dental caries.

Several studies have reported a large variation in the fluoride content of different bottled water brands[1,3-4,6,9-11]. Furthermore, studies of bottled water brands available on the national or international market have shown that the fluoride content of the product is inadequate. They have demonstrated either a fluoride concentration below the necessary level to be effective for the prevention of dental caries[3-4,7,9,11] or a fluoride content above the concentration approved by law, which may increase the risk of development of dental fluorosis[2,10,14].

The results of the present study are consistent with other surveys in the northeastern Brazil, which report average fluoride concentrations varying from 0.06 to 0.26 mg/L[9]. Furthermore, in research performed in Australia by Cochrane et al.[4], 100% of the samples tested demonstrated fluoride concentrations below 0.08 mg F/L. Similar results were also observed in the northeastern region of England where the authors found a mean of 0.08 mg F/L[11]. These investigations show that, if bottled water is used as the primary source of drinking water, then consumers are at a higher risk of not receiving any benefit regarding dental caries prevention.

In contrast, Grec et al.[6], surveying bottled water in the state of São Paulo, recorded fluoride levels of as much as 2.04 mg F/L, which is above the fluoride content level approved by state law[6]. Villena et al.[10] gave a broader view studying bottled water brands commercialized throughout Brazil and found fluoride concentrations of up to 4.4 mg F/L. All these studies point out to the necessity of more rigorous control when it comes to the composition of bottled water.

The present study demonstrated that 85% of the analyzed bottled water brands are being commercialized as fluoridated, while only one brand sold in João Pessoa, presenting fluoride content over 0.1 mg/L, could be classified as such. This lack of concordance shown on these product labels has also reported by Villena et al.[10].

According to the Brazilian law, the label of bottled water has to display the 8 most predominant minerals as well as classify the water as fluoridated if it contains more than 1.5 mg F/L. Seventeen of the twenty brands studied in this research showed the fluoride content on the product label, only 3 brands showed concordance between the values found on analysis and the values stated on the label. Another common mistake occurs when regarding the classification of the product as fluoridated water. This study found that most products display on their label the fluoridated classification, despite presenting less than 1.0 mg/L fluoride. The majority of the studies realized around the world present results consistent with the ones found in the present study regarding the labeling of products[1-4,6-7,9-11, 17].

The inclusion of the actual fluoride content on the label would allow the consumer to be aware of the presence or absence of fluoride in his/her drinking water. This way, the consumer would be able to know the amount of ingested fluoride and then make an informed decision about the choice of drinking water[4].

The analysis of fluoride content of different batches (when available) (Table 2) of the same brand of bottled water showed that there was not variation among some brands of bottled water. Similar studies performed in Mexico and Australia showed some deviation between batches[4,18]. It is possible to postulate that seasonal variability in the volume of rainfall could result in fluctuations in the content of fluoride of the bottled waters. Therefore, it is necessary to carry out more studies aimed at verifying the reason for the variation between batches of the same brand.

The maximum fluoride concentration that may be consumed

Table 2 - Variation in fluoride content among batches and the p value.

Code	Fluoride concentration (mg/l)			p value
	Batch #1	Batch #2	Batch #3	
JP1	0.04	0.04	0.03	<0.0001
JP2	0.01	0.01	0.01	0.01
JP3	0.03	0.04	0.02	<0.0001
JP4	0.04	0.02	0.03	<0.0001
JP5	0.01	0.01	0.02	0.01
JP6	0.03	0.01	0.01	<0.0001
JP7	0.04	0.04	0.03	0.002
JP8	0.27	0.19	-	<0.0001
JP9	0.06	0.07	0.06	0.008
JP10	0.03	0.02	0.02	0.97
JP11	0.01	0.02	0.01	<0.0001
SL1	0.03	0.03	0.04	0.002
SL2	0.04	0.04	-	0.871
SL3	0.01	0.01	0.02	0.461
SL4	0.02	0.02	0.01	0.097
SL5	0.04	0.04	0.03	0.004
SL6	0.02	0.02	0.02	0.554
SL7	0.04	0.04	-	<0.0001
SL8	0.03	0.02	0.02	0.103
SL9	0.02	0.02	-	0.66

daily without incurring the risk of developing enamel fluorosis is estimated at 0.05 to 0.07 mgF/kg/ day[19-20]. The brands bottled water analyzed in this research demonstrated low fluoride content, thus would not represent a risk for developing fluorosis or an acute intoxication.

Given the large variability in fluoride content among batches and overall low levels of fluoride across all the bottled water brands surveyed, it is important to consider the need of more accurate surveillance of bottled water commercialized in João Pessoa and São Luís with respect to the fluoride content and to the accuracy of the information given on the labels.

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