ABSTRACT

Objectives: The aims of the present study were to evaluate the fluoride (F) concentrations in whole, defatted and chocolate milks commercially available in Brazil and to estimate the daily F intake from these sources. Material and Methods: F concentrations were determined for 23 brands of milks, after HMDS-facilitated diffusion, using a F ion-specific electrode. Possible F ingestion per kg body weight was estimated, based on suggested volumes of formula consumption, for infants aging 1 to 12 months. Results: F concentrations ranged from 0.02 to 1.6 µg/mL F for all brands analyzed. Whole and defatted milks had the lowest F concentrations, ranging from 0.02 to 0.07 µg/mL. With respect to chocolate milks, three brands had F concentrations above 0.5 µg/mL. Some brands of chocolate milks exceeded the dose regarded as the threshold level for the development of dental fluorosis, without taking into account other sources of fluoride intake. Conclusion: The high fluoride concentrations found in some brands of chocolate milks in the present study indicate that many products may be important contributors to the total fluoride intake, reinforcing the need of assaying fluoride content of foods and beverages consumed by small children.

Uniterms: Fluoride; Milk; Dental fluorosis

RESUMO

Objetivos: Os objetivos do presente estudo foram avaliar as concentrações de flúor (F) em leites integrais, desnatados e achocolatados disponíveis comercialmente no Brasil e estimar a ingestão diária de F a partir destas fontes. Material e Métodos: as concentrações de F foram determinadas em 23 marcas de leite, após difusão facilitada por HMDS, usando um eletrodo ion-específico para F. A ingestão provável de F por Kg de peso corporal foi estimada, baseando-se em volumes sugeridos de consumo de fórmulas infantis, para crianças entre 1 e 12 meses de idade. Resultados: As concentrações de F variaram entre 0,02 e 1,6 µg/mL para todas as marcas analisadas. Os leites integrais e desnatados apresentaram as menores concentrações de F, variando entre 0,02 e 0,07 µg/mL. Com relação aos leites achocolatados, três marcas apresentaram concentrações de F acima de 0,5 µg/mL. Algumas marcas de leites achocolatados excederam a dose de flúor reconhecida como o limite máximo de exposição a fim de se evitar o desenvolvimento da fluorose dentária, sem se considerar outras fontes de ingestão de F. Conclusão: As altas concentrações de F encontradas em algumas marcas de leites achocolatados no presente estudo indicam que muitos produtos podem contribuir significativamente para a ingestão total de F, reforçando a necessidade de se avaliar o conteúdo de F em alimentos e bebidas consumidos por crianças pequenas.

Unitermos: Flúor, Leite, Fluorose dentária.
INTRODUCTION

Fluoride is the most clinically used mean of reducing dental caries. Besides the decline in tooth decay, the widespread use of fluoride has contributed to an increase in the prevalence of dental fluorosis1. Since dental fluorosis results of excessive ingestion of fluoride during enamel formation, all sources that contribute to the total intake of this ion should be considered to evaluate the risk of development of dental fluorosis. Regarding infants, the major dietary intake constitutes the breast milk, cow’s milk and infant milk formulations, in which the fluoride content varies widely6,12,15,21.

Milk is a universal food for newborns and growing mammals and contains all of the essential nutrients for their development and growth12. Changes in infant feeding practices have occurred over the past 30 years2,8,9. A decline in breast feeding has been noted, whereby a considerable number of infants are weaned early and artificially fed before they are a month old15. Thus, the concentration of fluoride in cow’s milk and infant formula plays an important role in the supply of fluoride to infants.

Although cow’s milk is reported to have low fluoride concentrations8,15,18, some studies related wide variations in fluoride concentrations in dairy milks8,12,14,15. In addition, previous studies found high fluoride concentrations in ready-to-drink chocolate milks8,14. Thus, the aim of the present study was to evaluate the fluoride concentrations in whole, defatted and chocolate milks commercially available in Brazil and to estimate the daily fluoride intake from these sources.

MATERIAL AND METHODS

Twenty-three brands of UHT (ultra high temperature) milks were purchased in supermarkets of Bauru, São Paulo State, Brazil, in October 2004. They were divided into three groups, as follows: GI – chocolate milks, GII – whole milks and GIII – defatted milks. The division of the brands into the groups, as well as the manufacturers, is presented in Table 1.

The boxes of milks were opened on the day of the analysis and 1 mL of milk was used for fluoride analysis. Fluoride determinations were carried out after overnight HMDS-facilitated diffusion, as described by Taves19, using the ion-specific electrode (Orion Research, Cambridge, MA, USA, model 9609). A set of standards (ranging between 0.025-3.200 ppm F) was prepared, using serial dilution from a 100 ppm NaF stock solution (Orion #940907) and diffused in triplicate in the same way as the samples. The millivoltage potentials were converted to µg F using a standard curve with a coefficient correlation of r²=0.999. All samples were analyzed in triplicate.

RESULTS

Table 1 presents all brands of cow’s milk analyzed, divided into the three groups (chocolate, whole and defatted milks), the manufacturers, as well as the fluoride concentrations determined for all brands of milk (expressed in µg/mL). All whole and defatted milks had low fluoride concentrations, ranging from 0.02 to 0.07 µg/mL F. Among chocolate milks, we found higher fluoride concentrations, ranging from 0.04 to 1.6 µg/mL. Three brands of chocolate milks had fluoride concentrations above 0.5 µg/mL (Nestlé Nescau, Toddly pronto and Toddynho Vitaminado).

Average infant body masses and suggested volumes of formula consumption for infants from one to twelve months of age are shown in Table 2. Using these data, the possible daily fluoride ingestion per kg body mass, presented in Table 3, can be estimated. Daily fluoride intake (mg/ kg body weight) from whole and defatted milks ranged from 0.003–0.0110, 0.002–0.008 and 0.002–0.008, while daily fluoride intake from chocolate milks ranged from 0.006–0.240, 0.005–0.192 and 0.004–0.173, respectively for infants aging 1, 6 and 12 months.

DISCUSSION

In the present study, whole and defatted milks had low fluoride concentrations. The values found (0.02-0.07 µg/mL) are in accordance with other previous reports5,12,21. These low fluoride levels were expected because fluoride is poorly transported from plasma to milk, and concentrations of fluoride in milk remain low even when the intake of fluoride by the mammal is high18. Analyzing fluoride concentrations in whole and defatted milks in relation to daily fluoride intake per kilogram of body mass (Table 3), it can be concluded that the use of such products is safe, concerning the dosages believed to increase the risk of development of dental fluorosis7. Among the different types of milk analyzed in this study, these products may be the most consumed.

Regarding chocolate milks, fluoride concentrations varied widely among the brands analyzed. Three brands of chocolate milks had fluoride concentrations above 0.5 µg/mL: Nescau (Nestlé®) had 0.5 µg/mL F, while Toddly Pronto and Toddynho Vitaminado (both from Quaker®), had 1.6 µg/mL F. We had already found high fluoride levels in chocolate milks6,14, but we were not able to identify the possible source of fluoride. Powdered chocolate was previously analyzed (data not shown) and we found low fluoride levels (ranging between 0.05 and 0.09 mg/g), excluding cocoa as the possible fluoride source. When analyzing the values found for all brands of chocolate milks in the present study, we cannot explain the differences among fluoride levels of the brands of chocolate milks evaluated. The possibility of being a contamination of the specific date of production is remote. We have already analyzed foods and beverages (including Toddynho) produced in three different dates, and the differences among the dates of production were small and not statistically significant6. However, there is no information.
on the consumption of chocolate milks by infants. This does not allow the precise estimation of their contribution to the total daily fluoride intake.

It is considered that the optimal range of fluoride intake is 0.05-0.07 mg F/kg body weight/day\(^2\). Taking into account average body masses and suggested volumes of formula consumption for infants of one, six and twelve months of age (Table 3), it is observed that some brands of chocolate milks exceeded the upper limit of daily fluoride intake (Nestlé\(^a\) Nescau), or even exceeded the threshold level for development of dental fluorosis (Toddy Pronto and Toddyinho Vitaminado). The bioavailability of milk is another point to be considered. Due to the high calcium concentrations in milk, there is a possibility of diminution of

### TABLE 1- Fluoride content of the different types of milk analyzed

| Milk type              | Brand          | Manufacturer | [F] (µg/mL) |
|------------------------|----------------|--------------|-------------|
| Chocolate Milk (GI)    | Leco           | Vigor        | 0.22        |
|                        | Nestlé Nescau  | Nestlé       | 0.50        |
|                        | Toddy Pronto   | Quaker       | 1.60        |
|                        | Parmalat Chocolate | Parmalat   | 0.10        |
|                        | Toddyinho Vitaminado | Quaker   | 1.60        |
|                        | Batavo Chocomilk | Batavia    | 0.04        |
| Whole Milk (GII)       | Ômega 3 Parmalat | Parmalat   | 0.04        |
|                        | Ômega Plus Nestlé | Nestlé       | 0.06        |
|                        | Batavinho Batavo | Batavo       | 0.06        |
|                        | Parmalat 1º Crescimento | Parmalat | 0.07        |
|                        | Parmalat Morango | Parmalat    | 0.04        |
|                        | Molico Ca Nestlé | Nestlé       | 0.07        |
|                        | Parmalat Zimil | Parmalat    | 0.04        |
|                        | Jussara        | Jussara     | 0.03        |
|                        | Batavo         | Batavia     | 0.02        |
|                        | Leco           | Vigor       | 0.03        |
|                        | Italac         | Goiasminas  | 0.03        |
|                        | Parmalat       | Parmalat    | 0.02        |
| Defatted Milk (GIII)   | Jussara        | Jussara     | 0.02        |
|                        | Batavo         | Batavia     | 0.03        |
|                        | Leco           | Vigor       | 0.05        |
|                        | Italac         | Goiasminas  | 0.02        |
|                        | Parmalat       | Parmalat    | 0.05        |

### TABLE 2- Formula administration guide*

| Age (months) | Body mass (kg) | Suggested feedings | Total volume (mL) |
|--------------|----------------|--------------------|-------------------|
| 0-1          | 0-4            | 5 bottles of 120 mL | 600               |
| 1-2          | 4-5            | 5 bottles of 150 mL | 750               |
| 2-3          | 5-6            | 5 bottles of 180 mL | 900               |
| 3-6          | 6-8            | 4 bottles of 240 mL | 960               |
| 6-12         | 8-10           | 4 bottles of 270 mL | 1080              |

* Data from Mead Johnson, Crows Nest, NSW.
fluoride absorption from gastro-intestinal tract\textsuperscript{18,20,22}. Thus, the calculations made for these products could be overestimated. On the other hand, milk is also rich in fats, what are known to increase the lag time of the food or beverage in the stomach\textsuperscript{20,22}. Although milk is known to interfere with the rate of fluoride absorption, it is demonstrated that 67 to 82\% of total fluoride in milk is absorbed\textsuperscript{17}.

Our special attention concerns children older than 11 months, since this period coincides with the beginning of the development of the permanent teeth crowns. Even for brands that did not exceed the upper optimal limit of fluoride intake, the risk of development of dental fluorosis exists, because children at this age are fed with other foods than milk, ingesting fluoride from water, beikost and formulas, etc. The ingestion of these sources with other fluoride-rich products is a possibility that must be considered. It seems likely that fluoride intake from beikost rarely averages more than 0.02 mg/kg body weight/day\textsuperscript{4}. Mean daily fluoride intake from water by itself up to 9 months of age is usually < 0.05 mg\textsuperscript{11}. Powdered or liquid concentrated infant formulas, as well as soymilk, appear to have high fluoride concentrations\textsuperscript{3,4,5}. It is estimated that the fluoride intake of children aging 6 and 12 months from powdered milk-based formulas reconstituted with optimally fluoridated water is 0.145 and 0.116 mg/kg body weight/day, respectively\textsuperscript{9}, thus exceeding the optimal range of fluoride intake\textsuperscript{2}. It must be also considered that some parents start to use fluoride dentifrice when the first teeth erupt and it is known that fluoride ingestion from dentifrice is inversely related to the age of the child\textsuperscript{4,16}. However, a recent study by Brofitt, et al.\textsuperscript{1} has shown that the mean fluoride ingestion from dentifrice is negligible during the first twelve months.

Taking these situations together, total fluoride intake will be higher and probably will exceed the upper limit recommended for fluoride intake. Taking into account that enamel fluorosis can occur following either an acute or chronic exposure to fluoride during tooth formation\textsuperscript{7} this assumes a greater relevance, showing the importance of monitoring fluoride intake by small children. In this sense, dairy companies should consider providing information to the public on fluoride content of all dairy products. In addition, public health measures should be taken, informing the consumer with respect to fluoride ingestion and its

| Brand                        | Estimated F consumption from milk by infant (mg/kg/day) |
|------------------------------|---------------------------------------------------------|
|                              | 1 month (4 kg) | 6 months (8 kg) | 12 months (10 kg) |
| Leco                         | 0.033          | 0.026           | 0.024             |
| Nestlé Nescau                | 0.075          | 0.060           | 0.054             |
| Toddy Pronto                 | 0.240          | 0.192           | 0.173             |
| Parmalat Chocolate           | 0.015          | 0.012           | 0.011             |
| Toddyinho Vitaminado         | 0.240          | 0.192           | 0.173             |
| Batavo Chocomilk             | 0.006          | 0.005           | 0.004             |
| Ômega 3 Parmalat             | 0.006          | 0.005           | 0.004             |
| Ômega Plus Nestlé            | 0.009          | 0.007           | 0.006             |
| Batavinho Batavo             | 0.009          | 0.007           | 0.006             |
| Parmalat 1º Crescimento      | 0.011          | 0.008           | 0.008             |
| Parmalat Morango             | 0.006          | 0.005           | 0.004             |
| Molico Ca Nestlé             | 0.011          | 0.008           | 0.008             |
| Parmalat Zimil               | 0.006          | 0.005           | 0.004             |
| Jussara                      | 0.005          | 0.004           | 0.003             |
| Batavo                       | 0.003          | 0.002           | 0.002             |
| Leco                         | 0.005          | 0.004           | 0.003             |
| Italac                       | 0.005          | 0.004           | 0.003             |
| Parmalat                     | 0.003          | 0.002           | 0.002             |
| Jussara                      | 0.003          | 0.002           | 0.002             |
| Batavo                       | 0.005          | 0.004           | 0.003             |
| Leco                         | 0.008          | 0.006           | 0.005             |
| Italac                       | 0.003          | 0.002           | 0.002             |
| Parmalat                     | 0.008          | 0.006           | 0.005             |

TABLE 3- Estimated fluoride intake from milk
adverse effects.

CONCLUSION

The high fluoride concentrations found in some brands of chocolate milks in the present study, together with many others around the world, indicate that many products may be important contributors to the total fluoride intake, reinforcing the need of assaying fluoride content of foods and beverages consumed by small children.

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