Breakfast cereals and snacks are foodstuffs highly appreciated by children, and the possibility that they contain substantial amounts of fluoride, associated with their widespread consume, may make them important contributors to the total daily fluoride intake. The aim of this study was to analyze the fluoride content on several breakfast cereals (A) and snacks (B) purchased in Brazil. The analysis were made after HMDS-facilitated diffusion (Taves) using the ion-specific electrode (9609). Mean fluoride concentrations ± SD (range, unit µg F/g) were: A= 0.76 ± 0.60 (0.08-1.86, n=15) and B= 0.32 ± 0.09 (0.22-0.55, n=18). Our results suggest that the total amount of fluoride available in some products may contribute to the total daily fluoride intake. The product labels should provide information on their fluoride content to prevent fluorosis at the age of risk.

UNITERMS: Fluoride; Cereals; Food analysis; Dental fluorosis.

INTRODUCTION

It has been demonstrated that the incidence and, to a lesser extent, severity of dental fluorosis has increased in the last decade in both optimally fluoridated and non-fluoridated areas in many countries, as well as in Brazil\textsuperscript{7,12,18,23}. Thus, the study of the sources of fluoride intake deserves special attention. Among the main sources of fluoride intake are fluoridated water, powdered milk reconstituted with fluoridated water, inadvertent ingestion of fluoridated toothpaste, inappropriate use of dietary supplements, as well as foods and beverages processed with fluoridated water\textsuperscript{4,20}.

The dietary habits during infancy have changed substantially in the last decades and a large increase in the consumption of manufactured products has been observed\textsuperscript{12}. Monitoring of the fluoride intake requires knowledge on the fluoride content of the foodstuffs commonly consumed by children at the age of risk for dental fluorosis. Since the manufacturers are not required to have the fluoride content of their products displayed on the labels, it is possible to estimate the fluoride intake only through fluoride assay.

Several previous studies have determined the fluoride content of baby foods, such as milk\textsuperscript{1,3,14,28}, dinners and desserts\textsuperscript{8,13,21,22,25,29} and beverages\textsuperscript{1,5,15}. However, these studies have been limited mainly to products manufactured in North America.

Little information is available on products from Brazil\textsuperscript{5,10,24}. Those available were limited to a very small number of infant foods. Considering that breakfast cereals and snacks are foodstuffs highly appreciated by children, the possibility of containing fluoride among their components may make them important contributors to the total daily fluoride intake. Thus, the aim of the present study was to analyze the total fluoride content of foodstuffs usually consumed by Brazilian children.

MATERIALS AND METHODS

Nine product samples of breakfast cereals and nine of snacks were purchased in Bauru-SP (Table 1). Brand name,
food type, flavor, container size, lot number, and manufacturer’s name, address, and phone number were recorded for each food and beverage studied.

**Preparation and total fluoride analysis**

The products’ packages were opened on the day of the analysis. The amount analyzed was 0.20 g. The breakfast cereals and snacks were ground and mixed in 3mL of deionized water prior to fluoride analysis. Knowing the exact amount of breakfast cereals and snacks and deionized water used, the fluoride content of the original dry product could be calculated. For the snacks and some breakfast cereals, products manufactured in two different dates (different batches) were analyzed.

Fluoride determinations were carried out after overnight HMDS(hexamethyldisilazane) yl-facilitated diffusion (Taves², 1968) using the ion-specific electrode (Orion Research, Cambridge, MA, USA, model 9609). A set of standards (ranging between 0.100-0.800 ppm F) was prepared, using serial dilution from a 100 ppm NaF stock solution (Orion#940907) and diffused in triplicate. The millivoltage potentials were converted to mg F using a standard curve with a coefficient correlation of r³ = 0.99.

All samples were analyzed in duplicate. The mean repeatability of the readings, based on the duplicate samples, was 90.5 percent.

**RESULTS**

Table 1 shows all products analyzed, as well as the manufacturer and production site. Table 2 shows the fluoride concentration (µg/g) determined for all products purchased on two different dates of manufacturing. The mean ± SD (range, n) fluoride concentrations found were 0.76 ± 0.60 (0.08-1.86, n=15) and 0.32 ± 0.09 (0.22-0.55, n=18) for breakfast cereals and snacks, respectively. Most of the products had low fluoride concentrations, except four breakfast cereals (Leite Moça, Nescau, Snow Flakes and Snow Flakes Chocolate) that had mean fluoride concentrations of 1.53 µg/g (1.26-1.86, n=5). There were small differences in the fluoride concentrations determined for each product on the two different dates of manufacturing (Table 2). However, these differences are not important in terms of fluoride intake.

**DISCUSSION**

Many studies have demonstrated that knowledge of the fluoridated water sites is not enough to estimate the total fluoride intake by children, and the fluoride concentration of infant foods and beverages must be known. Although it is difficult to precisely determine the total fluoride intake from diet, it is clear that there are substantial variations in

<table>
<thead>
<tr>
<th>Product type</th>
<th>Manufacturer</th>
<th>Production site</th>
<th>Product name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfast cereals</td>
<td>Kellogg’s</td>
<td>Santo Amaro-SP</td>
<td>Chocos</td>
</tr>
<tr>
<td></td>
<td>Nestlé</td>
<td>Caçapava-SP</td>
<td>Froot Loops!</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sucrilhos Original</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sucrilhos Original Banana</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sucrilhos Original Chocolate</td>
</tr>
<tr>
<td>Snacks</td>
<td>Elma Chips</td>
<td>Itu-SP/Curitiba-PR/Sete</td>
<td>Leite Moça</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lagoas-MG</td>
<td>Nescau</td>
</tr>
<tr>
<td></td>
<td>Fritex</td>
<td>São Roque-SP</td>
<td>Snow Flakes Original</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Snow Flakes Chocolate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Sítio do Pica Pau Amarelo
the intake of different foods and beverages and in the fluoride content of these products. Since products are not required to have their fluoride content displayed, the dietary fluoride intake may only be determined through fluoride assay.

The optimal range of fluoride intake is considered to be of 0.05-0.07mg F/kg body weight/day. Most products analyzed in this study had low fluoride concentration (mean fluoride concentration was 0.76 and 0.32µg/g for breakfast cereals and snacks, respectively). The fluoride concentrations found in breakfast cereals (Table 2) are within the same range as those reported in infant cereals by Vlachou, et al. (0.63 to 1.17 µg F/g), Dabeka, et al. (1.24 to 4.89 µg F/g), Buzalaf, et al. (0.43 to 6.64 µg F/g) and Buzalaf, et al. (0.20 to 7.84 µg F/g); there was a consistency of values obtained from the same product manufactured on different dates. The amount of fluoride in most of these products suggests that they may not significantly contribute to the daily fluoride intake.

However, four products analyzed (Leite Moça, Nescau, Snow Flakes and Snow Flakes Chocolate) had considerable fluoride concentrations (mean fluoride concentration of 1.54µg/g) and may be considered additional risk factors for dental fluorosis, especially when associated to other fluoride sources (Table 2). The breakfast cereals that had the highest fluoride concentration were calcium-rich products (12% calcium), as displayed on their labels. The high fluoride concentrations found in these products may be due to the calcium source added during manufacturing. Since the presence of calcium may diminish the fluoride absorption by the gastro-intestinal tract, it is possible that these calcium-rich cereals contribute little to dietary fluoride bioavailability.

One important factor to be considered is that breakfast cereals are usually mixed with milk. When 30g (one package) of Leite Moça, Nescau, Snow Flakes and Snow Flakes Chocolate are consumed just once a day, it means approximately 0.05mg F, which may provide 5-7% of the maximum total desirable fluoride intake per day (0.07mg F/kg body weight /day) for a 2-year-old child, weighing around 12 kg. If 30g of those products are added to 125mL of milk, as recommended on the labels, the fluoride content of the milk or other liquid must be considered. Cow’s milk is known to have a low fluoride content, yet powdered or liquid concentrated infant formulas may also be used. Therefore, the fluoride present in the water used to reconstitute these formulas must be considered. Furthermore, some children mix these breakfast cereals with ready-to-drink chocolate milks and some of them have been shown to have a high fluoride content. In addition, another liquid that may also be mixed to the breakfast cereals is soy milk.

TABLE 2: Fluoride content (mean unit µg/g) of breakfast cereals and snacks in two different dates of manufacturing (different batches)

<table>
<thead>
<tr>
<th>Product type</th>
<th>Product name</th>
<th>Fluoride concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Batch 1</td>
</tr>
<tr>
<td>Breakfast cereals</td>
<td>Chocos</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>Froot Loops!</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Sucrilhos Original</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>Sucrilhos Original Banana</td>
<td>0.62</td>
</tr>
<tr>
<td></td>
<td>Sucrilhos Original Chocolate</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>Leite Moça</td>
<td>1.69</td>
</tr>
<tr>
<td></td>
<td>Nescau</td>
<td>1.26</td>
</tr>
<tr>
<td></td>
<td>Snow Flakes Original</td>
<td>1.40</td>
</tr>
<tr>
<td></td>
<td>Snow Flakes Chocolate</td>
<td>1.86</td>
</tr>
<tr>
<td>Snacks</td>
<td>Cheetos Queijo Temperado</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>Cheetos Requeijão</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>Fandangos Queijo</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>Fandangos Pizza</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>Fandangos Presunto</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>Sítio** Batata</td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td>Sítio** Cebola</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>Sítio** Pizza</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>Sítio** Requeijão</td>
<td>0.40</td>
</tr>
</tbody>
</table>

*Only one batch was analyzed for some products
**Sítio do picapau amarelo
which contains higher fluoride contents than cow’s milk
and this has been attributed to higher endogenous levels of
fluoride in the soy extract.

The high fluoride content for those four breakfast cereals
may be explained by their manufacturing process. During
manufacturing, infant dry cereals are processed in a slurry
and placed in a revolving drying drum. The water from the
slurry evaporates, and the fluoride from the water remains
in the cereal. Thus, the fluoride concentration of the water
used during processing can substantially affect the final
fluoride concentration. Fomon and Ekstrand reported that
fluoride concentrations in dry cereals produced with
nonfluoridated or fluoridated water ranged from 0.09 to 0.20
and from 4 to 6µg F/g, respectively.

Another factor that must be taken into account is the use
of non-fluorine or fluorine-containing fertilizers in the grain
grow plots. A study was made of the fluorine-ion content in
the vegetables and grain grown on experimental plots of
land fertilized for 4-6 years with fluorine-containing
fertilizers, and the fluorine-ion content in individual samples
of the vegetables and grain was found to increase 2-32-fold
as compared to the control.

Our results showed that there was no significant variation
in the fluoride concentration between the products analyzed
in two different dates of manufacturing. This was also
observed for Brazilian manufactured foods. We tested this
variable because the fluoride concentrations for the majority
of the products vary primarily as a function of the different
fluoride concentrations in the water used to process them
and fluctuations in water fluoride concentrations are very
common. While this indicates that there may be no
significant variation in the fluoride content of the water
source at those specific locations, this assumption may not
be extrapolated to other products manufactured at other sites.

Another crucial factor when the association between
fluorosis and infant foods is considered is the critical period
of fluoride exposure for fluorosis development. Evans,
Darvell (1995) showed that the maxillary central incisor
appears most at risk to fluorosis from dietary fluoride
between fifteen and twenty-four months of age for males
and twenty-one and thirty months of age for females. This
way, the critical period for the anterior permanent teeth
would be after the first twelve months of life. At this time,
there is an increase in fluoride intake from manufactured
products.

This work showed that some breakfast cereals analyzed
should be important contributors to total daily fluoride intake
when associated with other fluoride-containing product. The
product labels should provide information on their fluoride
content.

RESUMO

Cereais matinais e salgadinhos são guloseimas altamente
apreciadas pelas crianças, e a possibilidade de conterem
quantidades substanciais de flúor, associada ao seu
indiscriminado consumo, pode torná-los importantes
contribuintes para a ingestão diária total de flúor. O objetivo
deste estudo foi analisar o conteúdo de flúor em diversos
cereais matinais (A) e salgadinhos (B) adquiridos no Brasil.
As análises foram feitas após difusão facilitada por HMDS
(Taves), usando o eletrodo ión específico (9609). As
concentrações médias de flúor ± SD (amplitude, unidade
µg F/g) foram: A= 0,76 ± 0,60 (0,08-1,86, n=15) e B= 0,32
± 0,09 (0,22-0,55, n=18). Nossos resultados sugerem que a
quantidade de flúor presente em alguns produtos pode
contribuir com a ingestão diária total de flúor. Os rótulos
dos produtos deveriam informar seu conteúdo de flúor para
preventir fluorose no período de risco.

REFERENCES

1- Adair SM, Wei HY. Suplemental fluoride recommendations
for infants based on dietary fluoride intake. Caries Res, 1978: 12
(2): 76-82.

2- Burt BA. The changing patterns of systemic fluoride intake. J

3- BUZALAF MAR, Granjeiro JM, Damante CA, Ornelas F.
Fluoride content of infant formulas prepared with deionized,
bottled mineral and fluoridated drink water. J Dent Child 2001;
68(1):37-41.

4- Buzalaf MAR, Whitford GM, Cury JA. Fluoride exposures and
dental fluorosis: a literature review. Rev Fac Odontol Bauru 2001;

5- Buzalaf MAR, Granjeiro JM, Duarte JL, Taga ML. Fluoride
content of infant foods in Brazil and risk of dental fluorosis. ASDC

6- Buzalaf MAR, Granjeiro JM, Damante CA, Ornelas F.
Fluctuations in public water fluoride level en Bauru, Brazil. J

7- Correia Sampaio F, Ramm von der Fehr F, Arnb erg P, Petrucci
Gigante D, Hatloy A. Dental fluorosis and nutritional status of 6-
to 11-year-old children living in rural areas of Paraiba, Brazil.

8- Debeka RW, McKenzie AD, Conacher HBS, Kirkpatrick DC.
Determination of fluoride intakes by infants. Can J Public Health,

9- Evans WR, Darvelll BW. Refining the estimate of the critical
period for susceptibility to enamel fluorosis in human maxillary

10- Fernandes DRM, Tabchoury CM, Cury JA. Concentração de
flúor em alimentos infantis e risco de fluorose dental. Pesq Odont

11- Fomon SJ, Ekstrand J. Fluoride intake by infants. J Public
Health Dent 1999; 59 (4): 229-34.


Recebido para publicação em: 07/02/2003
Enviado para reformulações em: 26/05/2003
Pronto para publicação em: 11/06/2003

Corresponding address:
Department of Biological Sciences, Bauru Dental School, University of São Paulo, Brazil.
Dr. Marília Afonso Rabelo Buzalaf
A1. Octávio Pinheiro Brissola, 9-75
Bauru-SP
Brazil
17012-901