FLUORIDE CONCENTRATIONS IN COMMERCIALLY AVAILABLE PROCESSED BEVERAGES IN BRAZIL CONSUMED BY INFANTS

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ABSTRACT: *Purpose:* **To determine fluoride concentrations of processed fruit juices (n=42) and ready-to-drink chocolate milks (n=9) commercially available in Araçatuba, Brazil, as well as estimating their contribution to the daily fluoride intake (DFI).** *Materials and methods:* **The beverages were purchased at supermarkets in Araçatuba, Brazil, and their fluoride contents were analyzed using an ion-specific electrode after overnight hexamethyldisiloxane (HMDS)-facilitated diffusion. The data were submitted to descriptive analysis.** *Results:* **The mean (SD) fluoride concentrations of the juices and chocolate milks were 0.17 (0.15) and 0.19 (0.21) µg F/mL, respectively, with a range for all the beverages considered together of 0.02–0.62 µg F/mL. The ranges of the values of the estimated DFI from these beverages in 2-year-old children, ranged from 0.0003–0.0091 F/kg body weight/day for a consumption of 200 mL/day and 0.0004–0.0136 mg F/kg body weight (bw)/day, for a consumption of 300 mL/day.** *Conclusion:* **Some of the products analyzed may be important contributors to the DFI and, therefore, can be regarded as potential risk factors for dental fluorosis, especially after considering the additional exposure from other sources.**

Keywords: Fluorides; Fruit and vegetable juices; Milk; Dental fluorosis.

INTRODUCTION

The use of fluoride is regarded as one of the main reasons for the decline in caries prevalence worldwide. However, an excessive and cumulative intake of fluoride during the critical period of enamel formation may lead to the development of dental fluorosis.[1] Although the exact dose that could trigger dental fluorosis development remains unknown, the so-called optimum fluoride intake is believed to range from 0.05 to 0.07 mg/kg body weight (bw).[1]

Because of the risk of dental fluorosis, the fluoride concentrations of several products have been frequently assessed, including the natural beverages consumed by children.[2,3] However, important changes in the eating habits of infants have been observed over the years, mainly characterized by an increasing consumption of processed foodstuffs. In Brazil, studies show not only a high consumption of processed beverages, but also their early introduction in the diet of children.[4] In addition to processed fruit juices, particular attention has been given to sweetened and flavored ready-to-drink milks, which have also been introduced in infants' feeding routines.

Considering the above scenario and that information on the fluoride content in these beverages is not available on the labels, the present study aimed to evaluate the fluoride concentrations of fruit juice and ready-to-drink chocolate milks, as well as to estimate the contribution of these products to the daily fluoride intake.

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METHODS

Processed fruit juices (n=42) and ready-to-drink chocolate milks (n=9), that were available in the supermarkets in the city of Araçatuba (SP), Brazil, had their fluoride content analyzed. The commercial names of the beverages and their manufacturers are shown in Tables 1A–C and 2. The beverage packages were opened immediately before the analysis, after being vigorously shaken.

Table 1A. Fluoride concentration of the commercial brands of processed fruit juice and the amount of fluoride ingested, assuming an intake of 200 and 300 mL of each product, based on the average body weight (bw) of Brazilian two-year-old children (13.7 kg)

Processed fruit juice	Manufacturer	[F] (µg/mL)	Amount of F ingested (mg/kg bw) for an intake of fruit juice of 200 mL and 300 mL	
			200 mL [F] (mg/kg)	300 mL [F] (mg/kg)
KAPO – Pêssego	DEL VALLE	0.23	0.0034	0.0050
KAPO – Laranja	DEL VALLE	0.42	0.0061	0.0092
KAPO – Maracujá	DEL VALLE	0.62	0.0091	0.0136
KAPO – Morango	DEL VALLE	0.36	0.0053	0.0079
KAPO – Uva	DEL VALLE	0.36	0.0053	0.0079
KAPO – Abacaxi	DEL VALLE	0.41	0.0060	0.0090
Del Valle Mais Light – Pêssego	DEL VALLE	0.24	0.0035	0.0053
Del Valle Mais Light – Uva	DEL VALLE	0.21	0.0031	0.0046
Del Valle Frut – Uva	DEL VALLE	0.45	0.0066	0.0099
Del Valle Frut – Tangerina	DEL VALLE	0.54	0.0079	0.0118
Del Valle – Laranja Caseira	DEL VALLE	0.30	0.0044	0.0066
Del Valle Mais – Manga	DEL VALLE	0.29	0.0042	0.0064
Maguary – Caju	MAGUARY	0.02	0.0003	0.0004
Maguary – Manga	MAGUARY	0.02	0.0003	0.0004
Maguary light – Goiaba	MAGUARY	0.02	0.0003	0.0004
Maguary light – Pêssego	MAGUARY	0.06	0.0009	0.0013
Vitakids – Pêssego	MAGUARY	0.08	0.0012	0.0018

Table 1B. Fluoride concentration of the commercial brands of processed fruit juice and the amount of fluoride ingested, assuming an intake of 200 and 300 mL of each product, based on the average body weight (bw) of Brazilian two-year-old children (13.7 kg)

Processed fruit juice	Manufacturer	[F] (µg/mL)	Amount of F ingested (mg/kg bw) for an intake of fruit juice of 200 mL and 300 mL	
			200 mL [F] (mg/kg)	300 mL [F] (mg/kg)
Vitakids – Maracujá	MAGUARY	0.04	0.0006	0.0009
Vitakids – Uva	MAGUARY	0.05	0.0007	0.0011
Vitakids – Laranja	MAGUARY	0.06	0.0009	0.0013
SuFresh – Goiaba	SUFRESH	0.07	0.0010	0.0015
SuFresh – Pêra	SUFRESH	0.03	0.0004	0.0007
SuFresh – Abacaxi	SUFRESH	0.15	0.0022	0.0033
Turma da Mônica – Pêssego	SUFRESH	0.03	0.0004	0.0007
Turma da Mônica – Uva	SUFRESH	0.08	0.0012	0.0018
Turma da Mônica – Maçã	SUFRESH	0.03	0.0004	0.0007
Purity – Laranja	PURITY	0.10	0.0015	0.0022
Purity – Uva Branca	PURITY	0.16	0.0023	0.0035
Purity – Uva	PURITY	0.13	0.0019	0.0028
Purity – Guaraná com Açaí	PURITY	0.12	0.0018	0.0026
Da Fruta Premium – Pêssego	DA FRUTA	0.05	0.0007	0.0011
Da Fruta Premium – Uva	DA FRUTA	0.03	0.0004	0.0007
Tampico – Manga	TAMPICO	0.12	0.0018	0.0026
Tampico – Frutas Cítricas	TAMPICO	0.11	0.0016	0.0024
Ceres – Lichia	CERES	0.19	0.0028	0.0042
Ceres – Uva Branca	CERES	0.15	0.0022	0.0033

Table 1C. Fluoride concentration of the commercial brands of processed fruit juice and the amount of fluoride ingested, assuming an intake of 200 and 300 mL of each product, based on the average body weight (bw) of Brazilian two-year-old children (13.7 kg)

Processed fruit juice	Manufacturer	[F] (µg/mL)	Amount of F ingested (mg/kg bw) for an intake of fruit juice of 200 mL and 300 mL	
			200 mL [F] (mg/kg)	300 mL [F] (mg/kg)
Nec Frut – Maracujá	LÍDER	0.08	0.0012	0.0018
Nec Frut LÍDER light – Uva	LÍDER	0.30	0.0044	0.0066
Taeq light – Pêssego	TAEQ	0.19	0.0028	0.0042
Frupic	FRUPIC	0.08	0.0012	0.0018
Fruthos – Laranja	FRUTHOS	0.05	0.0007	0.0011
Juxx – Ameixa	JUXX	0.32	0.0047	0.0070

Table 2. Fluoride concentration of the commercial brands of ready-to-drink-chocolate milk and the amount of fluoride ingested, assuming an intake of 200 and 300 mL of each product, based on the average body weight (bw) of Brazilian two-year-old children (13.7 kg)

Ready-to-drink chocolate milk	Manufacturer	[F] (µg/mL)	Amount of F ingested (mg/kg bw) for an intake of fruit juice of 200 mL and 300 mL	
			200 mL [F] (mg/kg)	300 mL [F] (mg/kg)
UHT Chocolate milk KAPO	DEL VALLE	0.24	0.0035	0.0053
UHT Chocolate milk Ovomaltine	OVOMALTINE	0.15	0.0022	0.0033
UHT Chocolate milk Danette	DANONE	0.04	0.0006	0.0009
UHT Chocolate milk Choco LECO	VIGOR	0.27	0.0039	0.0059
UHT Chocolate milk Qualitá	QUALITÁ	0.02	0.0003	0.0004
UHT Chocolate milk – Choco Milk	BATAVO	0.02	0.0003	0.0004
UHT Chocolate milk – Choco	LÍDER	0.08	0.0012	0.0018
UHT Chocolate milk Toddynho	QUAKER	0.53	0.0077	0.0116
UHT Chocolate milk Toddy Pronto	QUAKER	0.62	0.0091	0.0136

The fluoride content was analyzed using an ion-specific electrode (Orion Research, Cambridge, MA, USA, model 9409) and a miniature calomel reference electrode (Accumet No.13-620-79), both coupled to a potentiometer (Orion Research, model 720+), after overnight hexamethyldisiloxane (HMDS)-facilitated diffusion.[5] All the readings were performed in triplicate.

The data were analyzed by descriptive analysis. For the estimation of the fluoride intake, the mean consumption volumes of the beverages were considered according to Grimes et al.[6] The daily fluoride intake was estimated, for a daily consumption of 200 and 300 mL of beverage, for a 2-year-old child (average weight of 13.7 kg for Brazilian children),[7] as this group has the highest risk of dental fluorosis in the permanent incisors.[1]

RESULTS

The fluoride concentrations of processed fruit juices and ready-to-drink chocolate milks are presented in Tables 1A–C and Table 2. The fluoride content of all beverages ranged from 0.02 to 0.62 µg/mL, with a mean (SD) concentration of 0.17 (0.15) and 0.19 (0.21) µg/mL, respectively, for the processed fruit juices and the ready-to-drink chocolate milks.

The range of values for the amount of fluoride ingested by the 2-year-old children (13.7 kg) for a consumption of 200 mL/day of processed fruit juice was 0.0003–0.0091 mg F/kg bw/day and for a consumption of 300 mL/day it was 0.0004 –0.0136 mg F/kg bw/day (Tables 1A–C).

Similarly, the range of values for the amount of fluoride ingested by the 2-year-old children (13.7 kg) for a consumption of 200 mL/day of ready-to-drink chocolate milk was 0.0003–0.0091 mg F/kg bw/day and for a consumption of 300 mL/day it was 0.0004–0.0136 mg F/kg bw/day (Table 2).

DISCUSSION

Changes in infant feeding patterns[8] from natural to industrialized foods and beverages have made it difficult to estimate the daily consumption of nutrients and ions, including fluoride. Several studies have noted the importance of monitoring the fluoride content of processed foods and beverages in view of the wide fluctuations observed in the fluoride levels in such products which may result from differences in the intrinsic fluoride content in the ingredients, including the water used in the production.[1]

Despite most of the beverages analyzed presenting only low fluoride concentrations, some products could markedly contribute to the total daily fluoride intake. Taking the upper limit of the so-called optimum fluoride intake as 0.07 mg/kg bw and given that only 20% of the total fluoride intake is derived from foods and beverages in children under 3 years of age (~80% is associated with the use of fluoridated dentifrices),[8] fluoride ingestion from foods and beverages should not exceed 0.014 mg/kg bw. For a daily ingestion by a 2-year-old child of 200 or 300 mL of processed fruit juices, the fluoride intake from some beverages reached values of 0.007–0.009 and 0.010–0.014 mg F/kg bw/day, respectively. Considering the fluoride intake from other food items throughout the day, it becomes clear that the upper limit of fluoride ingestion from foods and beverages of 0.014 mg F/kg bw could easily be exceeded. For the ready-to-drink chocolate milks, the values obtained in the present

study were similar to those previously reported[9] including the high levels observed for the products "Toddynho" and "Toddy Pronto", which for a daily ingestion of 200 mL and 300 mL reached levels of 0.008–0.009 and 0.012–0.014 mg F/kg bw, respectively.

Unlike infant formulations and infant-friendly milks, processed fruit juices and ready-to-drink chocolate milks are not essential to the diet of children, so that they may be regarded as only complementary sources of nutrients and ions. However, the increasing consumption of these beverages may significantly contribute to the total daily fluoride intake, depending on their intrinsic fluoride levels. Furthermore, although the range from 0.05 to 0.07 mg/kg bw is considered the most acceptable optimum daily fluoride intake, it is still not clear whether this range is safe for preventing the development of dental fluorosis and effective for caries prevention.[1] It is noteworthy that dental fluorosis has been identified in individuals whose daily fluoride intake was lower than 0.03 mg/kg,[1] so that the contribution of fluoride from foods and beverages may be underestimated when considering the above-mentioned optimum daily range.

Previous surveys have demonstrated the influence of the fluoride levels in the water used in the processing of foods and beverages on the resulting fluoride concentrations in these products.[9] In line with these observations, the present study showed that the fluoride concentrations in the beverages from the same manufacturer do not present wide variations and that some manufacturers consistently presented the highest values among all juices (e.g., Del Valle), with only a minor influence from the flavor. Similarly, the ready-to-drink chocolate milks from the same manufacturer (e.g., Quaker) presented the highest concentrations among the similar beverages analyzed. Since the most common ingredient used in the manufacturing process is water, it may be suggested that the water fluoride levels exert the most influence on the final fluoride concentration of the product. As the fluoride present in processed beverages and foods is not intentionally added, the manufacturers may be unaware of the fluoride content in their products, so that this information is not provided on the labels. Considering the absence of legislation that obligates manufacturers to control and report the fluoride concentrations in their products, periodic monitoring becomes essential.[1]

Despite some products being identified as potential risk factors for the development of dental fluorosis, it is important to point out that the estimations provided may not directly relate to the systemic levels of fluoride resulting from the consumption of these products, as several variables have been shown to influence fluoride metabolism and, therefore, the degree of fluoride absorption after ingestion.[1] Furthermore, although the literature suggests that the contribution of beverages to the total water consumption varies with respect to the sociodemographic, lifestyle, and dietary characteristics of the population,[10] it is reasonable to consider that the intake of beverages may reduce the water consumption throughout the day, which could result in a compensation for the fluoride intake from beverages. Nonetheless, such estimations are useful to guide researchers and policy makers in implementing strategies to minimize systemic exposure from these products.

CONCLUSIONS

The present study suggests that the growing consumption of processed fruit juices and ready-to-drink chocolate milks by young children may significantly contribute to the total daily fluoride intake, and that some of the products analyzed can be considered as potential risk factors for the development of dental fluorosis. Public health measures could contribute to adequate monitoring of the fluoride levels in foods and beverages consumed by children at the ages where they are at risk of dental fluorosis.

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