TOTAL FLUORIDE CONTENT OF POWDERED INFANT FORMULA ON THE THAI MARKET

Saowaros Kaophun[1], Nattha Pattaravisitsate[1], Anucha Sacharoen[1] and Praphasri Rirattanapong[2]

Research Office[1], Department of Pedaitric Dentistry[2], Faculty of Dentistry, Mahidol University, Bangkok, Thailand

Abstract. Dental fluorosis can occur due to excessive fluoride intake among children aged 6-36 months. Powdered infant formula in Thailand does not show the fluoride content; therefore, we conducted this study to determine the fluoride content of powdered infant formula intended for children aged 6-36 months sold in Thailand. We determined the fluoride content of all 17 domestic and foreign powdered infant formula brands sold in Thailand in triplicate using the micro-diffusion method. The mean [±standard deviation (SD)] fluoride content of the studied brands was 0.308 (±0.07) mgF/l (range: 0.236-0.394 mgF/l). There were no significant differences in the fluoride content among the mean fluoride content values among the 3 replicates of this study. The measured fluoride content in the studied brands contains less than the maximum fluoride content. This suggests the risk for developing dental fluorosis due to consumption of the examined powdered infant formula brands is low. However, if the formulas examined are mixed with fluoridated water, there is an elevated risk for developing dental fluorosis.

Keywords: dental fluorosis, total fluoride, powdered infant formula, Thailand

INTRODUCTION

Adequate fluoride intake can prevent tooth decay (CDC, 2001). However, excess fluoride intake can result in dental fluorosis (CDC, 2001; Hong *et al*, 2006). Dental fluorosis can occur in children aged 15-30 months resulting in tooth enamel abnormalities (Evans and Darvell, 1995) because the teeth during this stage of development are susceptible to high fluoride levels. A survey conducted in 2012 by the Division of Dental Health, Department of Health, Ministry of Public Health Thailand (2012) found the prevalence of dental fluorosis among Thai children to be 9.2%.

Breastfeeding provides essential nutrients for infants (Ballard and Morrow, 2013). It should be started soon after birth; exclusive breastfeeding for up to 6 months is recommended by the World Health Organization (WHO, 2004). After age 6 months, infants should receive appropriate complementary feeding with continued breastfeeding for up to two years (WHO, 2004). However, some woman are unable or unwilling to breastfeed their infants (Ven and Greiner, 1981; Livingstone and Grams, 1985). This results in the need to substitute breast milk with powdered infant formula. Powdered infant formula consumption can result in dental fluo-

Correspondence: Nattha Pattaravisitsate, Research Office, Facultry of Dentistry, Mahidol University, 6 Yothi Road, Ratchathewi District, Bangkok 10400, Thailand.
Tel: +66 (0) 2200 7626
E-mail: nattha.pat@mahidol.ac.th

rosis among infants and young children (Winkle *et al*, 1995; Heilman *et al*, 1997; Fomon *et al*, 2000; CDC, 2001; Hujoel *et al*, 2009) especially when the milk is prepared with fluoridated water or bottled drinking water containing fluoride (Buzalaf *et al*, 2004). Studies among children in Sweden and United States have revealed that children fed powdered infant formula during the first 3-4 months of life had a greater risk of developing dental fluorosis than children who were breast fed only (Forsman, 1977; Walton and Messer, 1981). Most powdered infant formulas available commercially in Thailand have no fluoride content data on the label. This information is important for health professionals to decide on what fluoride supplements to use, if any, to reduce dental caries but not cause dental fluorosis.

The purpose of this study was to evaluate the fluoride content of powdered infant formulas sold on the Thai market in order to inform health care professionals and consumers about potential fluoride supplementation needs.

MATERIALS AND METHODS

We purchased 17 brands of powdered infant formula for children aged 6-36 months in supermarkets of Thailand. Fifteen cow's milk based formulas and 2 goat's milk-based formulas were selected for examination and purchased from three different lots of each type of formula to determine if any significant variability existed among the samples.

Conway Diffusion Cells were used to isolate the fluoride in the sample using the hexamethyldisiloxane (HMDS) facilitated diffusion (Taves, 1968). The diffused fluoride was trapped in alkali 1M NaOH (Whitfod, 1996). The fluoride was isolated after overnight diffusion (Opydo-Szymaczek and Opydo, 2011). The final solution was mixed with total ionic strength adjustment buffer (TISAB III) following the manufacturer instructions. The total fluoride content of each sample was determined using the direct read method with a fluoride ion selective electrode (Orion, Model 96-04, Beverly, MA) and an expandable ion analyzer (EA940; Expotech, Houston, TX). Each brand was analyzed in triplicate; three batches of the same formula per batch. The fluoride content was measured and reported in milligrams of fluoride per liter (mg F/l). The one-way ANOVA was used to determine the significance of the differences using a 95% confidence interval.

RESULTS

A total of 17 powdered infant formulas were examined for this study. Table 1 shows the fluoride content contained in 1 gram of each sample; for cow's milk based formulas the fluoride content had a range of 0.238-0.394 mgF/l and for goat's milk based formulas the fluoride content had a range of 0.236-0.243 mgF/l. The mean (±SD) fluoride content of all formulas examined was 0.308 (±0.07) (range: 0.236-0.394) mgF/l. The brand with lowest fluoride content was DG-2 Advanced Gold Goat Milk and the brand with the highest fluoride content was Nestle NAN® optipro HA® 2. The one-way ANOVA test revealed no significant difference in fluoride content by brand ($p>0.05$).

DISCUSSION

Dental fluorosis is caused by excessive fluoride intake among children aged 15-30 months (Evans and Darvell, 1995). Milk is the main source of calories for children aged 1-12 months (Chuckpaiwong *et al*, 2000). We studied the fluoride content

Table 1
Fluoride content and estimated fluoride consumption per day among studied powdered infant formulas.

Brand	Country of original	Average fluoride content per batch in mg F/l			Mean (±SD) fluoride content in mgF/l	Fluoride intake in mg/kg/day for a child aged 6-12 months (8-10 kg)
		Batch 1	Batch 2	Batch 3		
Cow's milk-based formula						
Enfalac A+ 360 DHA Plus 2™	Thailand	0.331	0.274	0.349	0.318±0.43	0.034
Enfalac 2 Smart+™	Thailand	0.373	0.313	0.318	0.334±0.07	0.036
Lactogen 2 Lcomfortis Happy Nutri™	Philippines	0.372	0.348	0.362	0.361±0.02	0.039
Hi-Q Prebio ProteQ™	Thailand	0.270	0.285	0.298	0.284±0.06	0.031
Hi-Q Super Gold Synbio ProteQ™	Thailand	0.273	0.211	0.252	0.245±0.04	0.027
Hi-Q H.A. 2 Prebio ProteQ™	Netherlands	0.396	0.355	0.322	0.357±0.05	0.039
Dumex Gold Plus Advanced komplete™	Thailand	0.255	0.262	0.255	0.258±0.04	0.028
Dumex Dopro Super Mix™	Thailand	0.314	0.332	0.271	0.305±0.05	0.033
Dumex Gold Plus 2 Advanced Komplete™	Thailand	0.280	0.372	0.323	0.325±0.06	0.035
Similac comfort 2 AI.Q Plus	Spain	0.244	0.274	0.297	0.271±0.06	0.029
Similac 2 AI.Q Plus Intalli-Pro™	Singapore	0.203	0.267	0.244	0.238±0.08	0.026
NAN® optipro HA® 2	Germany	0.376	0.434	0.371	0.394±0.05	0.043
S-26® Promil Gold Wyeth Biofactors™	Singapore	0.373	0.388	0.389	0.383±0.03	0.041
S-26 Promil 360° Smart care	Singapore	0.371	0.365	0.345	0.360±0.04	0.039
Bear Brand Advance Protext L-ProtexTus bifidus BL™	Thailand	0.351	0.283	0.338	0.324±0.05	0.035
Goat's milk-based formula						
DG-2 Goat Milk	New Zealand	0.236	0.257	0.235	0.243±0.02	0.026
DG-2 Advance Gold Goat Milk	New Zealand	0.236	0.224	0.247	0.236±0.03	0.025
Total mean values		0.309	0.308	0.307	0.308±0.07	0.033

SD, standard deviation; F, fluoride.

Table 2
Estimated formula consumption per day (Buzalaf *et al*, 2004).

Age (mos)	Body mass (kg)	Suggested feedings	Total volume (ml)
0-1	0-4	5 bottles of 120 ml	600
6-12	8-10	4 bottles of 270 ml	1,080

of powdered infant formulas sold for children aged 6-36 months to determine the risk for developing dental fluorosis from consumption of the studied formulas.

The mean (± SD) fluoride content of the studied formulas we examined was 0.308 (±0.07) (range: 0.236-0.39) mg F/l. This is similar to the results of studies by Adair and Wei (1978) (0.38 mg F/l), Johnson and Bawden (1987) (0.38 mgF/l) and Nagata *et al* (2016) (0.31 mg F/l).

When we estimated the total milk consumption per day, none of the studied formulas provided a fluoride content in excess of the daily recommended fluoride intake of 0.07 mg/kg (Anonymous, 1986), as long as the water used to make the powdered formula into milk did not contain fluoride. Our findings are similar to Buzalaf *et al* (2004).

There was some variation in fluoride content by brand but this did not differ significantly. Therefore, the risk for fluorosis is dependent on the fluoride content of the water used to mix the formula into milk. In our study, we used deionized water to mix with the powder formula. Deionized water is low in fluoride content and does not interfere with analysis (Buzalaf *et al* 2004). Powdered infant formula can contribute to dental fluorosis when mixed with fluoridated water (Silva and Reynolds, 1996). In a previous study, fluoride content in drinking bottled water in Thailand had a range of 0.01-0.89 mg F/l (Rirattanapong and Rirattanapong, 2016). Using water with a fluoride content of >0.29 mg F/l with the studied powdered infant formulas we studied would result in the child receiving a fluoride consumption greater than the recommended daily amount (≤ 0.07 mg/kg).

Other food sources potentially containing fluoride must also be taken into consideration because fluoride content exceeding 0.1 mg/kg can cause dental fluorosis (Siew *et al*, 2009). The data from our study show the fluoride content of the studied powdered infant formulas is not high enough to cause dental fluorosis but if the formula is mixed with fluoridated water, there is a risk for dental fluorosis.

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