FLUORIDE CONTENT OF COMMERCIALLY AVAILABLE SOY MILK PRODUCTS IN THAILAND

Opas Rirattanapong[1] and Praphasri Rirattanapong[2]

[1]Surin Dental Care Clinic, Mueang, Surin; [2]Department of Pediatric Dentistry, Faculty of Dentistry, Mahidol University, Bangkok, Thailand

Abstract. In Thailand, the consumption of soy milk products is common but there is limited data about their fluoride content. The purpose of this study was to estimate the fluoride content of soy milk products available in Thailand. Fluoride content was determined for 76 brands of soy milk using a F-ion-specific electrode. The fluoride concentrations ranged from 0.01 to 3.78 μg/ml. The fluoride content was not related to sugar content, soy bean content or the sterilization process. Among 3 brands of soy milk containing tea powder extract, the fluoride content was high (1.25 to 3.78 μg/ml). Most brands of soy milk tested in our study had fluoride content below the optimal daily intake but brands containing tea powder extract if consumed by children may increase their risk for fluorosis.

Keywords: soil milk, fluoride content, fluorisis, Thailand

INTRODUCTION

Milk consumption is common among children in many countries. Rao (1984) reported fluoride in milk can enhance remineralization of deciduous teeth. However, high concentrations of fluoride in milk consumed by infants and young children can increase their risk for developing dental fluorosis (Stephen *et al*, 1984). Dental fluorosis is a deficiency in enamel mineralization due to excessive daily fluoride intake during tooth development (Denbesten and Li, 2011). The highest risk period for developing fluorosis in permanent maxillary central incisors is birth to 6 years old (Mascarenhas, 2000). Hong *et al* (2006a) found the greatest risk period to be the first two years of life.

Optimum daily dose of fluoride for children should be 0.05-0.07 mg/kg and the maximum dose to avoid fluorosis is 0.1 mg/kg (Hong *et al*, 2006b). There is an increasing prevalence of dental fluorosis which could be attributable to increased fluoride content in foods and beverages, fluoridation of drinking water, inadvertent ingestion of fluoride in toothpaste, and inappropriate use of dietary supplements (Burt, 1992).

Soy milk has become a popular replacement for cow's milk. Soy milk has the same amount of protein as cow's milk and is a good source of dietary fiber, vitamins and minerals (Hajirostamloo, 2009). For people with lactose intolerance or cow's milk allergies, soy milk is an available alternative (Jooyandeh, 2011).

A study from Thailand in 2012 found the percentage of children aged 12 years

Correspondence: Praphasri Rirattanapong, Department of Pediatric Dentistry, Faculty of Dentistry, Mahidol University, 6 Yothi Road, Ratchathewi, Bangkok 10400, Thailand.
Tel: 66 (0) 2200 7821 ext 30
E-mail: praphasri.rir@mahidol.ac.th

who had dental fluorosis was 7.3% (Department of Dental Public Health, 2013). The fluoride content in soy milk is important for children; too much may contribute to dental fluorosis. Therefore, we aimed to determine the fluoride content of commercially available soy milk products in Bangkok, Thailand.

MATERIALS AND METHODS

We selected 76 soy milk products from 25 different brands. Pasteurized soy milk products were kept in the refrigerator at 4ºC and ultra-high temperature (UHT) sterilized soy milk products were kept at room temperature until examined. Each sample was analyzed in triplicate. Each sample was opened on the day of examination; 10 ml of each sample was examined for fluoride content using an ion-specific electrode (Orion Research, Cambridge, MA, model 96-09) after buffering with an equal volume of TISAB III (Taves, 1968). A series of standardized control samples with fluoride concentrations ranging from 0.01 to 10 ppm were prepared to calibrate the fluoride measurements.

The validity of the analyzed method was checked by adding a known amount of fluoride content to 10% of the samples (n=8). The reliability of the analyzed method was examined by reanalyzing with another 8 samples. The mean repeatability of the fluoride readings based on the triplicate samples was 97.8%. Results were reported as means, medians and ranges for the fluoride concentration.

RESULTS

The mean (SD) and median (range) for the fluoride content for each of the studied samples are shown in Table 1. The fluoride content for all the samples studied ranged from 0.01 to 3.49 μg/ml with a mean of 0.24± 0.46 μg/ml. Three samples (3.9%) had a fluoride content >0.7 μg/ml.

Table 2 shows the mean (SD) and median (range) fluoride concentrations by type of soy milk. The fluoride content did not vary significantly by type of sterilization (pasteurized *vs* UHT) or sugar content (sweetened *vs* unsweetened).

DISCUSSION

The fluoride content of soy milk samples analyzed in our study had a greater range of variation than a study by Lal *et al* (2014) (0.01 to 0.96 μg/ml) or Silva and Reynolds (1996) (1.08 to 2.86 μg/ml).

Most of the soy milk samples analyzed in the present study had a fluoride content <0.5 μg/ml. However, the soy milk samples containing tea or green tea powder extract had a high fluoride content (1.25 to 3.78 μg/ml). This is not surprising because studies have reported the high fluoride content of tea (Fung *et al*, 1999; Buzalaf *et al*, 2002; Lu *et al*, 2004).

The optimal of fluoride intake per day for children aged 1-12 years is 0.05-0.07 mg/kg (Levy *et al*, 1995). The sample in our study with highest fluoride concentration (3.78 μg/ml) if consumed by a 10 kg child every day would provide 100% of the recommended fluoride content per day and when combined with other dietary source of fluoride would increase the risk for fluorosis (Opydo-Szymaczele and Opydo, 2010).

The fluoride content of cow's milk ranges from 0.02 to 08 μg/ml (Tinanoff and Mueller, 1978; Vlachou *et al*, 1992). Therefore, the fluoride contents of soy milk samples in this study were higher than the fluoride content of cow's milk.

Table 1
Mean (SD) and median (range) of fluoride concentrations among soy milk products studied by brand, production site and soy bean content.

Brand	No. of sample	Production site	Labelled soy bean content range (%)	Mean±SD (μg/ml)	Median (range) (μg/ml)
Vitamin	10	Thailand	85.28 - 94	0.17 ± 0.03	0.17 (0.13-0.23)
Lactasoy	6	Thailand	89.3 - 91.97	0.29 ± 0.61	0.05 (0.01-1.53)
DNA	6	Thailand	82.29 - 96.62	0.25 ± 0.01	0.26 (0.24-0.27)
V-soy	4	Thailand	72.3 - 95.1	0.15 ± 0.01	0.15 (0.13-0.16)
Tofusan	4	Thailand	87.4 - 100	0.23 ± 0.10	0.22 (0.13-0.37)
Marusan	3	Thailand	93.4 - 94.7	1.63 ± 1.74	1.35 (0.04-3.49)
Homesoy	3	Thailand	81.6 - 92.8	0.11 ± 0.00	0.12 (0.11-0.12)
Anmum	2	Thailand	82 - 87	0.05 ± 0.03	0.05 (0.02-0.08)
Ohayo	2	Thailand	93 - 100	0.12 ± 0.05	0.12 (0.09-0.16)
Laban Soy Milk	2	Thailand	89 - 89.95	0.13 ± 0.07	0.13 (0.08-0.19)
Fong Fong	1	Thailand	84	0.08 ± 0.00	0.08
Soy To	1	Thailand	75	0.25 ± 0.01	0.25
Shin Po	1	Thailand	96.4	0.02 ± 0.00	0.02
My Choice	1	Thailand	94	0.13 ± 0.01	0.13
Tofu	1	Thailand	98	0.06 ± 0.00	0.06
Kikoman Pearl	5	USA	94	0.02 ± 0.01	0.01 (0.01-0.04)
Silk	3	USA	93 - 95	0.53 ± 0.04	0.51 (0.49-0.58)
West soy	2	USA	90 - 91	0.38 ± 0.00	0.38 (0.37-0.38)
Natur-a	4	Canada	85 - 88	0.09 ± 0.05	0.08 (0.06-0.16)
So Good	3	Australia	92.1 - 95.1	0.02 ± 0.00	0.18 (0.01-0.02)
So Natural	2	Australia	4 - 93	0.18 ± 0.04	0.18 (0.09-0.28)
Australia's own	1	Australia	95	0.90 ± 0.02	0.9
Tesco Oraganic	2	United Kingdom	6	0.25 ± 0.00	0.25 (0.25-0.26)
Pororo	3	Korea	58	0.08 ± 0.01	0.08 (0.07-0.09)
Binggrae	4	Korea	85.85 - 90	0.04 ± 0.00	0.04 (0.04-0.04)

Our findings are similar to previous studies (Clifford *et al*, 2009; Zohoori *et al*, 2012) that the fluoride contents of soy-based infant formulas were higher than other infant formulas.

The sugar content of sweetened soy milk samples tested in our study varied (0.5%-7.85%); 72.9% of the samples did not identify the sugar content of the soy milk. Twelve UHT soy milk samples had cane sugar, 3 pasteurized soy milk samples had raw sugar, 2 UHT soy milk samples had sucrose, 1 UHT soy milk sample had sugar obtained from apple extract and 1 pasteurized soy milk sample had brown sugar. The fluoride content did not vary significantly by the sugar content or type of sugar. Schamschula *et al* (1979) found the fluoride content of brown sugar was higher than white or raw sugar.

The soy bean content of the samples also varied. One product (Tofusan) had 100% soy beans while another product (So Natural) had only 4% soy beans. The

Table 2
Mean (SD) and median (range) fluoride concentrations (μg/ml or ppm) among soy milk products studied by sterilization method and sugar content.

Category	No. of sample	Fluoride concentration (μg/ml or ppm)	
		Mean±SD	Median (range)
UHT soy milk			
Unsweetened	4	0.24 ± 0.16	0.29 (0.01-0.38)
Sweetened	64	0.25 ± 0.50	0.14 (0.01-3.49)
All UHT	68	0.27 ± 0.51	0.14 (0.01-3.49)
Pasteurized soy milk			
Unsweetened	2	0.21 ± 0.07	0.21 (0.16-0.26)
Sweetened	6	0.20 ± 0.05	0.20 (0.17-0.22)
All pasteurized	8	0.20 ± 0.01	0.20 (0.16-0.26)
All soy milks	76	0.24 ± 0.46	0.14 (0.01-3.49)

fluoride content did not vary significantly by the soy bean content.

Fluoride content has been reported to vary by heat treatment process (Beddows and Balke, 1982; Liu *et al*, 1995) but we did not find in this study.

Sixty-one point eight percent of the soy milk samples in our study were produced in Thailand; the others were from the United State, Canada, Australia, United Kingdom and Korea. Liu *et al* (1995) found large variation in the fluoride content by production location but we did not find that in our study.

Soy milk prepared by the same manufacturer had similar fluoride content in our study except for the samples containing tea powder extract. The variation of fluoride content in our study depended on the addition of tea powder extract, the type of water used and the process involved in making the product.

The risks for oral caries and fluorosis from the samples in our study would depend on the type consumed, the volume consumed and the weight and age of the consumer. Unfortunately, there was no information about fluoride content on the labels of any of the studied samples. Products with high fluoride level need more effective control of fluoride content, standardization of production methods and better labeling.

In conclusion, most of the soy milk products studied had fluoride contents below the optimal daily fluoride intake but soy milk product containing tea powder extract had high fluoride content and could increase the risk for dental fluorosis among young children.

REFERENCES

Beddows CG, Balke CJ. The status of fluoride in bovine milk II. The effect of various heat treatment processes. *J Food Technol* 1982; 17: 63-70.

Bureau of Dental Health. The 7th National Oral Health Survey, Thailand 2012 (in Thai). Nonthaburi: Department of Health, Ministry of Public Health, 2012. Available from: http://dental.anamai.moph.go.th/oralhealth/elderly/NS7.pdf

Burt BA. The changing patterns of systemic fluoride intake. *J Dent Res* 1992; 71: 1228-37.

Buzalaf MA, Granjeiro JM, Duarte JL, Taga ML. Fluoride content of infant foods in Brazil and risk of dental fluorosis. *ASDC J Dent Child* 2002; 69: 196-200, 125-6.

Clifford H, Olszowy H, Young M, Hegarty J, Cross M. Fluoride content of powdered infant formula meets Australian food safety standards. *Aust NZ J Public Health* 2009; 33: 573-6.

Denbesten P, Li W. Chronic fluoride toxicity: dental fluorosis. *Monogr Oral Sci* 2011; 22: 81-96.

Fung KF, Zhang ZQ, Wong JWC, Wong MH. Fluoride contents in tea and soil from tea plantations and the release of fluoride into tea liquor during infusion. *Environ Pollut* 1999; 104: 197-205.

Hajirostamloo B. Comparison of nutritional and chemical parameters of soymilk and cow milk. *World Acad Sci Eng Technol* 2009; 57: 436-8.

Hong L, Levy SM, Broffit B, *et al*. Timing of fluoride intake in relation to development of fluorosis on maxillary central incisors. *Community Dent Oral Epidemiol* 2006a; 34: 299-309.

Hong L, Levy SM, Warren JJ, Broffitt B, Cavanaugh J. Fluoride intake levels in relation to fluorosis development in permanent maxillary central incisors and first molars. *Caries Res* 2006b; 40: 494-500.

Jooyandeh H. Soy products as healthy and functional foods. *Middle-East J Sci Res* 2011; 7: 71-80.

Lal H, Zohoori FV, Omid N, Valentine R, Maguire A. The fluoride contents of commercially-available soya milks in the UK. *Br Dent J* 2014; 217: E8.

Levy SM, Kiritsy MC, Warren JJ. Sources of fluoride intake in children. *J Public Health Dent* 1995; 55: 39-52.

Liu C, Wyborny LE, Chan JT. Fluoride content of dairy milk from supermarket: a possible contributing factor to dental fluorosis. *Fluoride* 1995; 28: 10-6.

Lu Y1, Guo WF, Yang XQ. Fluoride content in tea and its relationship with tea quality. *J Agric Food Chem* 2004 14; 52: 4472-6.

Mascarenhas AK. Risk factors for dental fluorosis: A review of the recent literature. *Pediatr Dent* 2000; 22: 269-77.

Opydo-Szymaczek J, Opydo J. Fluoride content of beverages intended for infants and young children in Poland. *Food Chem Toxicol* 2010; 48: 2702-6.

Rao GS. Dieatry intake and bioavailability of fluoride. *Annu Rev Nutr* 1984; 4: 115-36.

Schamschula RG, Agus HM, Fong KH, Craig GG. The fluoride content of sugar. *J Dent Res* 1979; 58: 1915.

Silva M, Reynolds EC. Fluoride content of infant formulae in Australia. *Aust Dent J* 1996; 41: 37-42.

Stephen KW, Boyle IT, Campbell D, McNee S, Boyle P. Five-year double-blind fluoridated milk study in Scotland. *Community Dent Oral Epidemiol* 1984; 12: 223-9.

Taves DR. Separation of fluoride by rapid diffusion using hexamethyldisiloxane. *Talanta* 1968; 15: 969-74.

Tinanoff N, Mueller B. Fluoride content in milk and formula for infants. *ASDC J Dent Child* 1978; 45: 53-5.

Vlachou A, Drummond BK, Curzon ME. Fluoride concentrations of infant foods and drinks in the United Kingdom. *Caries Res* 1992; 26: 29-32.

Zohoori FV, Moynihan PJ, Omid N, Abuhaloob L, Maquire A. Impact of water fluoride concentration on the fluoride content of infant foods and drinks requiring preparation with liquids before feeding. *Community Dent Oral Epidemiol* 2012; 40: 432-40.