FLUORIDE CONTENT OF COMMERCIALLY AVAILABLE BOTTLED DRINKING WATER IN BANGKOK, THAILAND

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Abstract. The use of bottled drinking water may be a source of fluoride and could be a risk factor for fluorosis among infants and young children. The aim of this study was to evaluate the fluoride content of commercially available bottled drinking water in Bangkok, Thailand. Forty-five water samples (15 samples of plain water and 30 samples of mineral water) were purchased from several supermarkets in Bangkok, Thailand. Three bottles of each water sample were purchased, and the fluoride content of each sample was measured twice using a combination fluoride-ion selective electrode. The average reading for each sample was then calculated. Data were analyzed by descriptive statistics. Differences between mineral and plain water samples were determined by Student's *t*-test. The mean (±SD) fluoride content for all the water samples was 0.17 (±0.17) mg F/l (range: 0.01-0.89 mg F/l). Six brands (13%) tested stated the fluoride content on the label. The actual fluoride content in each of their brands varied little from the label. Eight samples (18%) had a fluoride content >0.3 mg F/l and two samples (4%) had a fluoride content >0.6 mg F/l. The mean mineral water fluoride concentration was significantly higher than the mean fluoride concentration of plain water (p=0.001). We found commercially sold bottled drinking water in Bangkok, Thailand contained varying concentrations of fluoride; some with high concentrations of fluoride. Health professions need to be aware this varying fluoride content of bottled drinking water and educate the parents of infants and small children about this when prescribing fluoride supplements. Consideration should be made to have fluoride content put on the label of bottled water especially among brands with a content >0.3 mg F/l.

Keywords: bottled drinking water, fluoride, fluorosis, mineral water, plain water

INTRODUCTION

Drinking water is usually the largest single contributor to daily fluoride intake (Murray, 1986). Bottled drinking water is frequently used in place of tap water because of convenience, pleasing taste, and perceived purity (Lalumandier and Ayers, 2000).There is a large demand for bottled drinking water in Thailand, but the water quality of commercially bottled water is unclear.

Manufacturers sometimes list the nutritional content of their products but

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labeling of the fluoride content of the products is not legally required in Thailand. If the fluoride content is written on the bottle label, it may not be accurate. The fluoride content of the bottled drinking water may vary. It is important to know the fluoride content of the bottled drinking water. High levels of fluoride could contribute to dental fluorosis among infants and children (Vlachou *et al*, 1992).

Health care professions should have information about fluoride content of bottled drinking water before prescribing fluoride supplementation. For this reason, we aimed to determine the fluoride content of commercially available bottled drinking water in Bangkok, Thailand.

MATERIALS AND METHODS

Forty-five commercially available samples of bottled drinking water were chosen from those available in major supermarkets and grocery stores in Bangkok, Thailand. Three bottles of each brand, each with a different batch number and date of bottling were purchased. The water examined included both mineral and plain water. The purchased samples were kept in their original plastic sealed containers at room temperature until examined.

Each sample was shaken first and then the bottle was opened and 1.0 ml was obtained and mixed with 0.1 ml of Total Ionic Strength Adjusting Buffer III (Zohouri and Rugg-Gunn, 1999). The fluoride content of each sample were determined twice using a Fluoride ion selective electrode (Orion,model 96-09, Beverly, MA) and an expandable ion analyzer (EA 940; Expotech, Houston, TX). Control samples with concentrations of fluoride ranging from 0.01 to 1.00 mg/l were used to calibrate the instrument. The pH of each water samples was also measured using a pH-meter (Orion 3 star; Expotech, Houston, TX). One batch number of the three bottles purchased of each brand was randomly selected and re-analysed to evaluate the reliability of the study.

Statistical analyses were used to evaluate the data. The paired *t*-test was employed to compare the first and second measurements of each sample. The one-way ANOVA test was used to compare the fluoride content among the different batches of the same brand and the Student's *t*-test was used to evaluate the differences between bottled plain and mineral water. A p-value <0.05 was considered statistically significant.

RESULTS

Of the 45 samples of water tested, 60% were produced in Thailand; 15 were plain water and 30 were mineral water. Our findings are recorded in Table 1, including those brands that did list the fluoride content. The accuracy of the method was confirmed by comparing the first and second readings of the sample; the differences were not statistically significant ($p = 0.23$). The reliability of the method of fluoride analysis was determined to be 99%. There were no significant differences in fluoride content among the three batches for each brand ($p= 0.37$). The mean (±SD) fluoride content for all brands sampled was 0.17(±0.17) mg F/l (range; 0.01-0.89 mg F/l). The highest mean fluoride concentration by brands was found in Perra mineral water from Thailand [0.87(±0.01) mg F/l]. All the imported brands had a low fluoride concentration (<0.3 mg F/l). Most of the brands sampled in our study had a low fluoride concentration. Eight brands (18%) [Singha, Nestle Pure

Table 1
Fluoride content of commercially available bottled water in Bangkok, Thailand.

Brand	Country of origin	Average fluoride content for each batch (mg F/l)			Mean (±SD) fluoride content in mg F/l	Labeled content of fluoride in mg F/l	pH of sample
		Batch1	Batch2	Batch3			
Plain water							
Seven Select	Thailand	0.02	0.02	0.02	0.02±.0.00	NL	6.79
Big C	Thailand	0.02	0.02	0.02	0.02±0.00	NL	6.93
My Choice	Thailand	0.01	0.01	0.01	0.01±0.00	NL	7.13
Tesco	Thailand	0.02	0.02	0.02	0.02±0.00	NL	6.62
Aeon	Thailand	0.02	0.02	0.02	0.02±0.00	NL	6.56
Home Freshmart	Thailand	0.01	0.01	0.01	0.01±0.00	NL	6.67
Aquafina	Thailand	0.01	0.01	0.01	0.01±0.00	NL	6.62
Namthip	Thailand	0.04	0.04	0.04	0.04±0.00	NL	6.61
Singha	Thailand	0.42	0.43	0.43	0.43±0.10	NL	8.05
Chang	Thailand	0.14	0.14	0.14	0.14±0.00	NL	7.53
Crystal	Thailand	0.02	0.02	0.02	0.02±0.00	NL	6.69
Polaris	Thailand	0.01	0.01	0.01	0.01±0.00	NL	6.54
Nestle Pure Life	Thailand	0.47	0.47	0.48	0.47±0.01	NL	7.63
Neptune	Thailand	0.10	0.10	0.10	0.10±0.00	NL	6.96
CP	Thailand	0.02	0.02	0.01	0.02±0.00	NL	6.80
Mineral water							
Seven Select	Thailand	0.23	0.23	0.23	0.23±0.00	NL	6.83
Big C	Thailand	0.05	0.05	0.05	0.05±0.00	NL	7.34
My Choice	Thailand	0.10	0.10	0.11	0.11±0.01	NL	8.08
Tesco	Thailand	0.43	0.43	0.43	0.43±0.00	NL	7.75
Aeon	Thailand	0.76	0.76	0.76	0.76±0.00	NL	6.74
Home Freshmart	Thailand	0.44	0.44	0.44	0.44±0.00	NL	8.22
Aura	Thailand	0.32	0.32	0.32	0.32±0.00	0.39	7.16
Perra	Thailand	0.86	0.89	0.88	0.87±0.01	0.7	6.75
Minere	Thailand	0.46	0.46	0.46	0.46±0.01	NL	7.78
Natural	Thailand	0.06	0.06	0.06	0.06±0.00	NL	7.50
Mont Fleur	Thailand	0.14	0.14	0.14	0.14±0.00	NL	6.95
Miracle Pi	Thailand	0.10	0.10	0.10	0.10±0.00	NL	7.30
Radnor Hills	United Kingdom	0.08	0.08	0.08	0.08±0.00	0.09	7.44
Iceland	Iceland	0.05	0.05	0.05	0.05±0.00	NL	8.30
Highland Spring	Scotland	0.05	0.05	0.05	0.05±0.00	NL	7.81
Evian	France	0.07	0.07	0.07	0.07±0.00	NL	7.16
Vittel	France	0.16	0.16	0.17	0.16±0.05	NL	7.24
Volvic	France	0.21	0.21	0.21	0.21±0.00	NL	7.38
Whistler	Canada	0.03	0.03	0.03	0.03±0.00	0	6.80
Fiji	Fiji Islands	0.25	0.25	0.25	0.25±0.00	NL	7.31
Lunares	Spain	0.24	0.24	0.24	0.24±0.00	NL	7.45
Alteza	Spain	0.17	0.17	0.17	0.17±0.00	NL	8.00
Solan de Cabras	Spain	0.09	0.09	0.09	0.09±0.00	<0.2	7.52
Font Dor	Spain	0.22	0.22	0.22	0.22±0.01	NL	7.83
Acqua Panna	Italy	0.04	0.04	0.04	0.04±0.00	NL	7.70
San Benedetto	Italy	0.05	0.05	0.05	0.05±0.00	0.006	7.59
Wildalp	Austria	0.03	0.03	0.03	0.03±0.00	NL	7.43
Suisai No Mori	Japan	0.18	0.18	0.18	0.18±0.00	NL	7.58
Asahi	Japan	0.09	0.09	0.09	0.09±0.00	NL	7.88
Icis	Korea	0.07	0.07	0.07	0.07±0.00	NL	7.73

life, Tesco (mineral), Aeon (mineral), Home Freshmart (mineral), Aura, Perra, Minere] had a fluoride content >0.3 mg F/l; of these two (4%) (Perra, Aura) had a fluoride content >0.6 mg F/l. The mean mineral water fluoride concentration was significantly higher than the mean plain water fluoride concention (p =0.001). Only 6 of 45 samples (13%) listed their fluoride content on the label.

DISCUSSION

The fluoride content of bottled drinking water in our study varied widely. This is similar to studies done in the other countries (Zohouri and Rugg-Gunm, 1999; Ahiropoulos, 2006; Aldrees and Al-Manea, 2010; Jerri, 2015).

Some of the mineral water samples in our study contained greater fluoride concentrations than the plain water. Ramires *et al* (2004) defined mineral water as any water obtained directly from natural springs or artificially extracted from subsoil that is characterized by a defined and constant content of mineral salts and by the presence of trace elements and other components. Collection of this type of water should be conducted under conditions that ensure the maintenance of the origin features found at their well or spring, have no variation in content from the original source water and have no direct influence from surface water (Ramires *et al*, 2004). However, when plain water is treated before it is bottled, fluoride might be lost.

Plastic-bottled water samples were chosen for this study because fluoride binds to glass bottles (Mills *et al*, 2010). For this reason, the fluoride content of glass-bottled water may be lower than the original fluoride content of the water (Weinberger, 1991).

The pH of drinking water should be 6.5-8.5 (WHO, 2003). The range of pH values in this study was 6.5-8.3.

Six brands (13%) listed the fluoride content of the water on the label. The actual fluoride content in each of these brands varied little from the labels. These minor variations discrepancies might be due to multiple water production sites for a single company and the seasonal fluctuation in the fluoride of the water source (Cochrane *et al*, 2006). The inclusion of the fluoride content on the label allows the consumer to be aware of the amount of fluoride and make an informed choice about the type of drinking water consumed (Cochrane *et al*, 2006).

The fluoride content of bottled drinking water has implications for the use of fluoride supplements and the risk for fluorosis. The recommended level of fluoride in the water for warm countries like Thailand is 0.6-0.7 mg F/l, due to the larger amount of water consumption in the hot climate compared to temperate countries (AIdosari *et al*, 2003). The American Academy of Pediatric Dentistry (2009) recommends fluoride supplements be considered for all children drinking water with fluoride content below 0.6 mg F/l. The American Academy of Pediatrics (1986) recommends the optimal intake of fluoride should be 0.05-0.07 mg per kilogram of body weight; to avoid dental fluorosis, fluoride intake should not exceed 0.1 mg fluoride per kilogram of body weight per day.

Two brands in our study (Perra and Aeon) had fluoride concentrations above 0.6 mg F/l. These could cause fluorosis if this water is consumed by an infant or a young child in addition to taking fluoride supplementation.

In conclusion, we found commercially available bottled drinking water in Bangkok, Thailand contained a variety of

concentrations of fluoride; two contained fluoride content high enough to cause fluorosis if used with fluoride supplements. Health professions should ask about the type of water consumed before prescribing fluoride supplementation for infants and young children.

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