INVESTIGATION OF THE FLUORIDE CONTENT OF EDIBLE SALT AND THE FLUORIDE INTAKE FROM EDIBLE SALT CONSUMPTION IN IRAN

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ABSTRACT: In order to estimate the fluoride ion (F) content of edible salt and the F intake from edible salt consumption in Iran, the F content was measured in 37 brands of edible salt consumed in Iran. The F analysis was made by the standard SPADNS method using a Spectrophotometer DR/5000s (HACH Company, USA). The mean F level of the edible salt was 0.0424±0.012 mg F/g of salt, with a range of 0.020–0.066 mg F/g salt. Based on an estimated mean salt intake in Iran of 9.9±2.9 g/day/person, the mean daily F intake from edible salt was calculated to be 0.420 mg F/day, range 0.212–0.696 mg F/day. After considering the daily salt intake and the levels of F in the drinking water in three provinces in Iran, Gilan, Mazandaran, and Ilam, the total daily intake of F from edible salt and drinking water for adults in these provinces was found to have a range of 0.96–1.21 mg F/day.

Keywords: Edible Salt; Iran; Salt Consumption; Salt Fluoridation.

INTRODUCTION

Groundwater is the major source of the fluoride ion (F) in endemic fluorosis areas.[1] The F level in groundwater is also positively related[2] to total hardness, noncarbonate hardness, and the levels of SO_4^{2-}, Ca^{2+}, and Mg^{2+}. In addition, food materials contribute considerably to the total F intake.[3,4] F is a potentially toxic element, when taken in excess through water or food.[5] The dietary intake of F through the consumption of food, drinking water, beverages, and tea has been viewed as an important cause of F-related health problems in many parts of the world.[4,6-8] Although the topical use of F has been recommended for the prevention of dental caries, F is not an essential element and is not necessary for the development of healthy bones and teeth.[9,10] The overconsumption of F in infancy may lead to dental fluorosis and other adverse effects including developmental neurotoxicity.[9-12] While dental fluorosis only occurs with a high F intake during the early childhood years while the teeth are developing, other adverse effects including skeletal fluorosis may develop at later ages.[13-18] For most people in Iran, the major source of F exposure is drinking water.[19] Most of the reports on the F concentrations in the drinking water and food are on water concentrations with only a few reports on the concentration of F in foods in various parts of the world. Only a limited number of studies have been done on the F content of edible salt in Iran which is counted as one of the F containing foods.[20] According to the studies conducted in Iran, the salt intake in Iranians exceeds the recommended standard of less than 5 g/day and the F intake from edible salt can be quite significant.[21] Thus, the aim of the present study was to estimate the daily F intake in Iran from edible salt, by determining the F content in edible salt consumed in Iran.

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MATERIALS AND METHOD

The F content of 37 brands of edible salt in Iran, produced by 37 factories, were analyzed (Table 1).

Table 1. Sampling sites and factories

Province tag	Province	No. in sample	No. of factories
A	Tehran	16	7
B	Esfahan	4	1
C	Fars	7	5
D	Hamedan	1	1
E	East Azarbaijan	4	1
F	West Azarbaijan	5	-
G	Ardabil	5	-
H	Semnan	3	12
I	Alborz	3	-
J	Kermanshah	1	-
K	South Khorasan	3	-
L	Markazi	6	2
M	Zanjan	6	-
N	Kerman	5	2
O	Bushehr	5	-
P	Ilam	4	-
Q	Qazvin	1	1
S	North Khorasan	1	-
T	Khuzestan	3	-
U	Kordestan	2	-
V	Chahar Mahal	1	-
W	QOM	2	3
X	Khorasan Razavi	1	2
Y	Lorestan	2	-
Total	24 provinces	91 samples	37 factories

The edible salt was mixed with deionized water with a specific conductance of less than 0.1 ms/cm to prepare solutions with 10 g salt/L for each brand and the F concentrations of the mixtures were measured. Edible salt products of the same brand with different production dates were mixed together in equal proportions to give a final concentration of 10 g salt/L for each brand. The F analysis was made by the standard SPADNS method using a Spectrophotometer DR/5000s (HACH Company, USA). As well as removing the chloride interference, multiple random samples with concentrations of 1 g salt/L were prepared and read. The locations of the factories producing the salt samples are shown in Figure 1.

Figure 1. The locations in Iran of the 37 factories producing the salt samples using the province tags shown in Table 1.

RESULTS

The measured concentration of F per g of edible salt in the samples of the various brands had a range of 0.020–0.66 mg F/ g salt, with a mean concentration of 0.0424±0.012 mg F/g salt (Table 2).

Table 2. Fluoride content per 1 gram of edible salt for each brand

Label for salt brand	Fluoride content (mg F/g edible salt)	Label for salt brand	Fluoride content (mg F/g edible salt)	Label for salt brand	Fluoride content (mg F/g edible salt)
S-1	0.053	S-14	0.021	S-27	0.065
S-2	0.038	S-15	0.066	S-28	0.038
S-3	0.043	S-16	0.020	S-29	0.034
S-4	0.037	S-17	0.035	S-30	0.033
S-5	0.047	S-18	0.020	S-31	0.056
S-6	0.034	S-19	0.042	S-32	0.056
S-7	0.031	S-20	0.048	S-33	0.052
S-8	0.026	S-21	0.065	S-34	0.044
S-9	0.032	S-22	0.058	S-35	0.049
S-10	0.034	S-23	0.050	S-36	0.060
S-11	0.037	S-24	0.044	S-37	0.039
S-12	0.026	S-25	0.063		
S-13	0.042	S-26	0.040		

Based on the studies in the literature, Rafiei et al. concluded that, the habitual dietary salt intake was high in Iran and estimated that the mean daily salt intake in Iran, based on urinary sodium excretion, was 9.9±2.9 g/d.[22] Therefore, using the mean F concentration of the edible salt available in Iran found in the present study of 0.0424±0.012 mg per g of salt.and the following equation, the mean daily F intake in Iran through edible salt was estimated as 0.420 mg F/day with a range of 0.212–0.696 mg/day.

$$\text{Mean daily intake of fluoride from edible salt (mg F/day)} = \text{Concentration of fluoride in edible salt (mg F/g of salt)} \times \text{Mean daily edible salt intake (g of salt/day)}$$

The mean daily salt intake in three Iranian provinces, Gilan, Mazandaran, and Ilam, with the capital cities of Rasht, Sari, Ilam, respectively, has been found to be 7.2±4.7, 7.7±4.0, and 9.0±4.3 g salt/day, respectively.[23,24] Thus, using the F concentration in edible salt of 0.0424 mg F/g salt, the mean fluoride intake from edible salt for the people living in these regions is 0.305, 0.326, and 0.382 mg F/ day, respectively.

The mean F concentrations in ground water in the capital cities, Rasht, Sari, Ilam, of the three provinces, Gilan, Mazandaran, and Ilam, respectively, have been found to be 0.45, 0.37, and 0.29 mg F/L[25] (Table 3).

Table 3. Fluoride concentrations (mg F/L) in the groundwater resources of Iran[25]

Province (capital city)	Fluoride concentration in ground water (mean±SD of fluoride concentration in mg F/L)
Gilan (Rasht)	0.45±0.26
Mazandaran (Sari)	0.37±0.29
Ilam (Ilam)	0.29±0.17

Assuming a daily water consumption of 2 L/day, we estimated the range of the mean daily F intake through edible salt[23,24] and drinking water[25] in the provinces of Gilan, Mazandaran, and Ilam, to be 0.96–1.21 mg F/day, respectively (Table 4).

Table 4. Daily fluoride intake through edible salt and drinking water (mg F/day)

Province	Mean fluoride intake through salt (mg F/day)	Mean fluoride intake through drinking water (mg F/day)*	Total mean fluoride intake through salt and drinking water (mg F/day)*
Gilan	0.305	0.90	1.21
Mazandaran	0.326	0.74	1.07
Ilam	0.382	0.58	0.96

*Daily intake of fluoride from drinking water = concentration of fluoride in drinking water (mg/L) × mean water consumption (L/day).

DISCUSSION

The present study showed that the mean F concentration of the edible salt available in Iran was 0.0424±0.012 mg per g of salt. Rafiei et al.[22] estimated that the mean daily salt intake, based on urinary sodium excretion, is 9.9±2.9 g/day among Iranians. Therefore, the F intake through edible salt was estimated to be 0.420 mg/day, with a range of 0.212 to 0.696 mg/day. According to previous

studies, the mean daily salt intakes in the three provinces of Iran of Gilan (capital city Rasht), Mazandaran (capital city Sari), and Ilam (capital city Ilam), are 7.2±4.7, 7.7±4.0, and 9.0±4.3 g salt/day, respectively, giving mean F intakes from salt for people living in these regions of 0.305, 0.326, and 0.382 mg F/day, respectively (Table 4).[23,24] After considering the F concentrations in the drinking water in the three Iranian provinces of Gilan, Mazandaran, and Ilam[25] (Table 3), we found the range for the total F intake through edible salt and drinking water to be 0.96–1.21 mg F/day (Table 4).

The World Health Organization (WHO), in its 1996 publication *Trace elements in human nutrition and health* classifies fluoride in the group of "potentially toxic elements, some possibly with essential functions."[26] However, in 2011 the Scientific Committee on Health and Environmental Risks (SCHER). of the European Commission, found that F was not an essential trace element and was not necessary for the formation of healthy bones and teeth.[10] The 1996 WHO report noted that total F intake of adults is usually in the range 0.2 to 2.0 mg F/day and that higher intakes were not uncommon when the F content of drinking water was high.[26] The report noted that, so far, there was no evidence from human studies the overt clinical signs of F deficiency exist.[26] No specifically diagnostic clinical or biochemical parameters have been related to F deficiency.[26] The Expert Consultation was therefore unable to specify a minimum desirable intake.[26] In view of the toxicity associated with excessive F ingestion from a variety of sources, recommendations were made for maximum safe intakes.[26] They stated that the total intakes at 1, 2, and 3 yr of age should, if possible, be limited to 0.5, 1.0, and 1.5 mg F/day, respectively, with not more than 75% in the form of highly soluble fluorides in drinking water.[26] They stated that adult intakes exceeding 5 mg of F/day from all sources probably pose a significant risk of skeletal fluorosis.[26] However, Hirzy et al. considered that the safe dose for children to be much lower and, using the Lowest Observed Adverse Effect Level/No Observed Adverse Effect Level (LOAEL/NOAEL) method, estimated the safe dose for children to be about 0.047 mg F/day.[27]

In a study similar to the present study, Haftenberger et al.[28] found that the total F intake from food and beverages in 11 pre-school children was 202.5±116.2 µg F/day. Similarly, Zohouri et al.[20] found that the range of F content in salt was 0.162 µg F/g salt, with a range of 0.001–0.567 µg F/g salt, and the F content for a mixed spice was 2.408 µg F/g mixed spice. Maupomé and Castaño.[29] measured the F content of 221 bags of salt in Mexico City, and this element was found to be below the amount recommended by the government. Zohuri et al.[3] reported that the total F intakes through the diet in Iranian children residing in low-F areas, including Shiraz, Darab, Dehkhir, and Hassan-Abad, were 0.318, 0.364, 0.575, and 0.440 mg F/day respectively. In another study, Faraji et al.[30] measured the F level in human breast milk and the F concentration in the drinking water used by mothers living in the northern part of Iran and showed that the F concentration in water can affect its concentration in breast milk. Exposure to high doses of F may also lead to dental fluorosis, skeletal fluorosis, increased rates of bone fractures, decreased

birth rates, increased rates of urolithiasis (kidney stones),[6] and lower intelligence in children.[11,31] F ingested during pregnancy can have an effect on the human fetus by passing through the placenta.[32] In areas with high concentrations of F in the drinking water, in order to reduce the daily F intake, it is recommended that F is removed from drinking water by an appropriate process.[33] For reducing the F intake through groundwater, the consumption of bottled water with a low F content is recommended.[34]

CONCLUSIONS

In this study all the edible salt samples had detectable levels of F. The F content in the human body depends on various factors, such as the amount of edible salt consumption, the F concentration in drinking water, the quantity of drinking water consumed, and the F content of other foods. The consumption of salt containing a high level of F will increase the F content in the human body. The results of the present study showed that the total daily F intake from drinking water and edible in three Iranian provinces to be 0.96–1.21 mg F/day. As a first step towards reducing the F intake from various sources, it is suggested that the amount of F in the drinking water in high drinking water F regions be adjusted according to the diet of the people of the region.

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