

ESTIMATION OF DIETARY INTAKE OF FLUORIDE FROM DIET AND DRINKING WATER IN EGYPT

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ABSTRACT

The present work is planned to estimate the daily total dietary intake of fluoride by the Egyptian citizen in diet and drinking water in order to know the effect of the fluoride level on general health and comparing this level with the international recommended acceptable limit. The daily intake of fluoride from diet was estimated using the total diet study. The method involves the purchase and preparation of the cooked foodstuffs commonly used in the diet. However, it does not include food consumed outside the home. These foodstuffs were combined into 12 groups of like foods as follow :- Bread and cereals; poultry; meat and meat products; fish; oil, fats, eggs and dairy products; sugars; vegetables; potatoes; canned vegetables; fresh fruit and fruit products; beverage and milk. Thirty samples, used in the house, from each of the twelve foodstuffs groups were collected monthly from 3 governorates (Cairo, Giza and Kalioubia) during the year 2003 and then estimate the fluoride concentration in each food group. The total fluoride intake (mg / person / day) was calculated in the different cited foodstuffs and was estimated to be: 0.374, 0.005, 0.009, 0.09, 0.07, 0.007, 0.001, 0.003, 0.019, 0.0007, 0.001 and 0.0017 mg/ person / day, respectively. Consequently, the daily intake of fluoride from diet was 0.58 mg / person / day. Drinking water samples were collected from ten governorates in Egypt. The fluoride content in tap water (the origin is River Nile) ranged from 0.330-0.377 mg / L with an average of 0.36 mg/L. The amount of drinking water consumed by the Egyptian citizen vary from 3188 to 3375 ml / day for adult and consequently the fluoride intake from drinking water ranged from 1.147 - 1.215 mg / day.

By comparing the results of the total fluoride intake in Egypt by the Egyptian citizen with the study presented by WHO 1984, it was found that the fluoride intake by the Egyptian citizen was 0.580 mg / person / day, whereas, the international fluoride intake was 0.344 mg / person / day. The average intake from tap water is estimated to be within the range of 1 to 1.5 mg / person/ day (WHO, 1984). The present study found that the daily intake of fluoride from drinking water ranged from 1.147 to 1.215 mg / person / day. By calculation, the total intake of fluoride set by (WHO, 1984) from diet and drinking water vary from 1.344 to 1.844 mg / person / day, whereas, the present study found that the total intake of fluorine by the Egyptian citizen in Egypt ranged 1.727 to 1. 795 mg/ person/ day. Consequently, the total intake of fluorine from diet and drinking water in Egypt by the Egyptian citizen falls within the safely recommended international limit.

INTRODUCTION

Fluoride is classified by the Food and Nutrition Board, National Academy of Science (1974) as an essential trace element in human nutrition. Fluoride intake by human is a result of ingestion of water and food (WHO, 1984). Water and food are the main sources of fluorine intake and the amount of fluorine absorbed by the body is related to the amount of water and type of food ingested by the individual (Osis *et al.*, 1974 and Hattab &

Wei, 1988). Because of the widespread distribution of fluoride in nature, it has not been possible to produce a diet that is completely deficient in this element, and its presence indicates some physiological importance to man (Waldbott, 1963). The World Health Organization (WHO, 1984) has set a maximum concentration of 1.5 ppm fluoride in drinking water. The significance of fluoride to human health derives from the fact that fluoride is considered to be one of the most successful method in dental caries prevention (Dijkman *et al.*, 1986). Dental caries is a major dental disease affecting the lives of a large proportion of the inhabitants of the world. It impairs the quality of life for many people by causing pain and sepsis and lack of treatment can aggravate other systemic diseases. Dental caries is a disease in which factors interact to produce irreversible destruction of the hard tissues of the teeth, enamel, dentine and cementum. Despite continuing efforts to develop methods of lowering the number of bacteria on teeth by mechanical means or by reducing their cariogenic activity with chemical agents (Leukhart, 1979; Marthofer, 1979 and Royal college of physicians, 1976). The proper use of fluoride remains the best defence against dental decay. At lower levels of intake, fluoride confers caries protection (Featherstone *et al.*, 1990), while excessive intake during the period of enamel formation can cause enamel fluorosis (Fejerskov *et al.*, 1987). The concentration of fluoride in the oral fluids is determined by oral exposure to fluoride in food and beverage (including water), dentifrice and other fluoride containing agent (Oliveby *et al.*, 1989). Fluoride abundance in soil and plants means that everyone consumes fluoride, whether he wants to or not. Absorption of fluoride from the diet, however, can vary from one individual to another. Some foods concentrate additional fluoride ions from boiling and processing. Fluoride ion concentration levels, in various food itmes vary widely, even between samples of the same kind of food (Waldbott, 1963). In this concern, Toth (1975) calculated the amount of dietary fluoride needed to substitute for the total fluoride contributed by drinking water. His calculations were based on body size, caloric intake, fluoride derived from foods of three age groups: for infants less than 2 years of age (10 kg) the optimal dose was 0.45 mg/day. For children 7 – 9 years (24 kg) the dose was 0.77 mg / day and for adult (65 kg) the dose was 1.45 mg /day. Older, frequently estimates the daily fluoride intake from food and beverages for an adult male have included 1-3 mg / day (Massier and Rose, 1972). The optimal percentage of fluoride in communal water supply prevent dental caries without producing mottling of the enamel was found to be 1 ppm (WHO, 1970 and Barmes, 1983). It reduces dental caries by approximately 60 % (National Academy of sciences, 1974). This is achieved by a daily fluoride intake of 0.5 to 1 mg F/ day in children and of 1 to 1.5 mg F/ day in adults (WHO, 1984). Several reviews concerning the fluoride content of foods have been presented (Kumpulainen & Koivistonen, 1977 and Beeker & Bruce, 1981).Levy (1994) and Burt (1999) stated that the dietary fluoride intake by man has received attention for many years. The daily dietary fluoride intake is based on the fluoride content of various food items prior to fluoridation of water. The present work is planned to estimate the dietary intake of fluoride in Egypt.

MATERIALS AND METHODS

A-Sampling

I-a. Diet

Twelve food stuffs groups shown in (Table 1) were purchased from 3 governorates (Cairo, Giza and Kalioubia), thirty prepared samples using all types of cooked food in the house were collected monthly during the year 2003 as follows:-

1- Bread and cereals

Wheat bread, wheat bread + maize, maize bread + Foenugreek, seed wheat, wheat flour, maize flour and macaroni.

2- Poultry

3- Meat and meat products

Meat of cows and buffaloes, sausages, lunchen, burger and cured meat.

4- Fish

5- Oils, fat, eggs and dairy products

Maize oil, sunflower oil, olive oil, cotton oil, artificial fat, natural fat, eggs, yoghurt, white cheese, cheddar, leicester and edam cheese.

6- Sugars

Sugar, honey, molasses, jam and halawa.

7- Cooked vegetables

Green bean, squash, spinach, cauliflower, cabbage, kolcasia, molokia, okra, pisum and mushroom.

8- Potatoes

9- Canned vegetables

Okra, molokai, string beans, pisum.

10-Fresh fruit and fruit products

a – Fresh fruit

Oranges, apples, pears, graps, lemon, banana, mango, date, gawava, apricot, plums, fig and pineapple.

b- Fruit products (canned fruit)

11-Beverages

Beverages, tea, coffee, anise, Foenugreek, karkadeh

12-Milk

Buffaloes milk, cows milk, dried milk and skimmed milk.

I -b. Drinking water (tap water)

Samples of drinking water (the main source is the River Nile) were taken after allowing the water to flow for five minutes. One liter was taken in a plastic container previously washed with distilled water, dried in air and washed with the water of the samples. Four samples were collected monthly for the year 2003 starting from January till december, from each of 10 governorates Cairo, Giza, Kalioubia, Fayoum, Menia, Dakahlya, Alexandria, Ismailia, Suez and Port said (480 samples)

B- Measurement of dietary intake of food

A range of different procedures are available for estimating the dietary intake of food (MAFF 1993). The estimation involves gathering data on food consumption. In this paper, Egyptian dietary intakes of fluoride has been estimated using the total diet study (Peattie *et al.*, 1983). This method involves the purchase and preparation, including cooking where and appropriate, of common foodstuffs in the national average diet. However, it does not include food consumed outside the home nor alcoholic beverages.

These foodstuffs were combined into 12 groups of like foods, the proportion of each food in each group reflecting the amount of that food in the average diet, and then the food groups were analyzed. Intakes were calculated from the knowledge of the weight of each group consumed and the concentration of fluoride in each food group. Fluoride concentration in food group samples was determined (Mcquaker and Gurney, 1977) and fluoride concentration in drinking water was determined according to (Standard method, 1984) using ATI ORION 960 (Ion – meter) using fluoride ion selective electrode 96 – 09 BN.

The electrode filling solution and the total ionic strength adjustment buffer solution (TISAB) were prepared as described in the electrode instruction manual.

C- Study of food intake for the Egyptian citizen

The average consumption of the Egyptian citizen (kg/ person/ day) were calculated for the twelve foodstuff groups by the Nutrition Research Institute (1981) as shown in table (1).

Table (1): Study of food intake for the Egyptian citizen*

Food Group	Average consumption	Average consumption
	(gm / person / day)	(kg / person / day)
Bread and cereals	1440	1.440
Poultry	32	0.032
meat products	122	0.122
Fish	82	0.082
Oils, fats, eggs and dairy products	94	0.094
Sugars	137	0.137
Vegetables	303	0.303
Potatoes	100	0.100
Canned vegetables	3	0.003
Fresh fruit and fruit products	73	0.073
Beverage (non alcoholic)	10	0.010
Milk	177	0.177

*Nutrition Research Institute, 1981.

RESULTS and DISCUSSION

Fluoride level in different food groups

Cereals and bread groups

Fluoride level in the combined " bread and cereals" food group was found to be 0.30 mg/ kg as shown in (Table 2) and the total intake was 0.072 (WHO, 1984). The present study shown in (Table 3) found mean level of 0.26 mg / kg and the total fluoride intake was 0.374 mg / person/ day. By comparing the results of the total intake in Egypt with the study presented by WHO 1984, it was found that the Egyptian intake exceed the intake presented by WHO due to the increased average consumption from this group.

Table (2): Total diet study in fluoride intake

Food Group*	Average* consumption (g / person / day)	Fluoride level**		Fluoride intake*** (mg / person / day)
		(mg / kg)		
		Mean	Range	
Bread and cereals	0.24	0.30	0.23-0.40	0.072
Poultry	0.059	0.21	0.1-0.3	0.012
It products	0.048	0.10	0.06-0.12	0.004
Fish	0.017	1.3	0.6-1.5	0.022
Oils, fats, eggs and dairy products	0.12	0.9	0.5-1.2	0.108
Sugars	0.090	0.01	0.01	0.0009
Vegetables	0.050	0.01	0.009-0.014	0.0005
Potatoes	0.18	0.22	0.19-0.26	0.035
Canned vegetables	0.042	0.3	0.28-0.39	0.012
Fresh fruit and fruit products	0.091	0.1	0.08-0.17	0.009
Beverage (non alcoholic)	0.66	0.1	0.09-0.18	0.066
Milk	0.34	0.01	0.01	0.0034
Total Intake				0.344

* MAFF, 1993.

** WHO, 1984

*** Fluoride Intake (mg/ person / day) = Average consumption (kg / person / day) X Fluoride concentration (mg / kg)

Meat and meat products

Fluoride level in the meat and meat products was measured and mean level was 0.1 mg / Kg and the total intake was 0.004 mg / person / day (WHO, 1984). The study in 2003, found mean fluoride level 0.08 mg / kg and the total intake was 0.009 mg / day. By comparison, the total intake in Egypt exceed the total intake presented by the study of WHO 1984.

Fish group

Fluoride level in the fish group was found to be 1.3 mg / kg and the total intake was 0.022 mg/person / day (WHO, 1984). The study in 2003 found mean fluoride level of 1.1 mg/ kg and the total intake was 0.09 mg / person / day. By comparison, the Egyptian intake is higher than the intake presented by WHO due the increased average consumption from this group.

Table (3): Estimated total dietary intake of fluorine (mg / person / day) in Egypt 2003.

Food Group*	Average* consumption (g / person / day)	Fluoride level(mg / kg)		Fluoride intake** (mg / person / day)	% fluoride intake
		Mean	Range		
Bread and cereals	1.44	0.26	0.21-0.32	0.374	64.48
Poultry	0.032	0.17	0.1-0.22	0.005	0.86
St products	0.122	0.08	0.05-0.11	0.009	1.55
Fish	0.082	1.1	0.6-1.2	0.09	15.51
Oils, fats, eggs and dairy products	0.094	0.8	0.5-1.1	0.07	12.06
Sugars	0.137	0.01	0.01	0.001	0.17
Vegetables	0.303	0.01	0.009-0.015	0.003	0.52
Potatoes	0.100	0.19	0.15-0.21	0.019	3.27
Canned vegetables	0.003	0.25	0.19-0.28	0.0007	0.12
Fresh fruit and fruit products	0.073	0.1	0.08-0.16	0.007	1.2
Beverage (non alcoholic)	0.01	0.1	0.09-0.15	0.001	0.17
Milk	0.177	0.01	0.01	0.0017	0.29
Total intake				0.58	

*Nutrition Research Institute, 1981.

**Fluoride intake(mg / person / day) = Average consumption (kg / person / day)x fluoride concentration(mg / kg)

$$\% \text{ fluoride intake} = \frac{\text{fluoride intake for each foodstuff group}}{\text{Total Intake (0.58)}} \times 100$$

Oils, fats, eggs and dairy products.

Fluoride level was measured and mean level found was 0.9 mg / kg (WHO, 1984) and the total intake was 0.108 mg / person / day. The study in 2003 found that mean levels of fluoride was 0.8 mg / kg and the total intake was 0.07 mg / person / day. By comparison, the Egyptian intake is lower than the total intake presented by the study of WHO 1984.

Fruit

Fluoride level was 0.1 mg / kg and the total fluoride intake was 0.009 mg / person / day. The study in 2003 found mean fluoride level of 0.1 mg / kg and the total intake was 0.007 mg / person / day. By comparison, the total intake in Egypt is less than the total fluoride intake presented by the study of WHO 1984 due to the decreased average consumption from this group.

Poultry

Fluoride level in the poultry group was measured and mean level found was 0.21 mg / kg and the total intake was 0.012 mg / day. The study in 2003 found mean fluoride level of 0.17 mg / kg and the total intake was 0.005 mg / person / day. By comparison, the total fluoride intake in Egypt is lower than the total intake presented by the study of WHO 1984.

Sugars

Fluoride level in the sugar group was measured and found to be 0.01 mg / kg and the total intake was 0.0009 mg / person / day. The study in 2003 found mean fluoride level of 0.01 mg / kg and the total intake was 0.001 mg / person / day. By comparison, the total fluoride intake is higher than the total intake presented by the study of WHO 1984 due to the increased average consumption from this group.

Potatoes

Fluoride level in the potatoes group was measured and mean fluoride level found was 0.16 mg / kg and the total intake was 0.035 mg / person / day (WHO, 1984). The study in 2003 found mean fluoride level of 0.19 mg / kg and the total intake was 0.019 mg / person / day. By comparison, the total intake in Egypt is lower than the intake presented by the study of WHO 1984 due to the decreased average consumption from this group.

Vegetables

The fluoride content of most vegetables is low and mean level was found to be 0.01 mg / kg and the total intake was 0.0005 mg / person / day (WHO, 1984). The study in 2003 found mean fluoride level of 0.01 mg / kg and the total intake was 0.003 mg / person / day. By comparison, the total intake in Egypt is higher than the intake presented by the study of the WHO 1984 due to the increased average consumption from this group.

Milk

Fluoride level in milk is very low (Backer Dirks et al, 1974). Fluoride level in the milk group was measured and mean level found was 0.01 mg / kg and the total intake was 0.0034 mg / person / day (WHO, 1984). The study in 2003 found mean fluoride level of 0.01 mg / kg and the total intake was 0.0017 mg / person / day.

It is clear that the total intake in Egypt is too much lower than the total fluoride intake presented by the study of the WHO 1984.

Canned vegetables

Fluoride level in the canned vegetable group was measured and mean level was 0.3 mg / kg and the total intake was 0.012 mg / person / day. The study in 2003 found mean fluoride level of 0.25 mg / kg and the total intake was 0.0007 mg / person / day. By comparison, the Egyptian total intake in this group is lower than the total intake prescribed by the WHO 1984 due to the decreased average consumption from this group.

Beverage (non alcoholic)

Fluoride level in the beverage group was measured and mean level found was 0.1 mg / kg and the total intake was 0.066 mg / person / day (WHO, 1984). The study in 2003 found mean fluoride level of 0.1 mg / kg and the total intake was 0.001 mg / person / day. By comparison, the total intake in Egypt is lower than the intake described by the WHO, 1984 due to the decreased average consumption from this group.

A- Fluoride level in drinking water

Data obtained from analysis of fluoride concentrations of tap water is shown in table (4). It is evident from these data that fluoride concentration of tap water obtained from 10 governorates of Egypt ranging from (0.333 to 0.377) mg / L with a mean of 0.36 mg / L. Water, naturally is the most important source of fluoride. The amount of fluoride intake from water is dependent on the fluoride content of water and on the amount of water

Table 4: Fluoride concentration as mg/L in drinking water all over the year 2003 from 10 governorates of Egypt.

Months Location	Jan.	Feb.	March	April	May	June	July	August	Sep.	Oct.	Nov.	Dec.	Average and Range
Cairo	0.340	0.338	0.336	0.333	0.340	0.342	0.345	0.335	0.332	0.322	0.326	0.310	0.333 0.310-0.345
Giza	0.378	0.372	0.376	0.353	0.356	0.351	0.380	0.368	0.362	0.359	0.350	0.356	0.363 0.350-0.380
Kallobia	0.352	0.359	0.354	0.338	0.337	0.335	0.356	0.349	0.342	0.336	0.330	0.339	0.344 0.330 - 0.356
Fayoum	0.381	0.379	0.373	0.365	0.367	0.382	0.372	0.375	0.372	0.366	0.363	0.366	0.372 0.363-0.382
Menia	0.349	0.344	0.346	0.353	0.369	0.372	0.380	0.369	0.362	0.342	0.355	0.341	0.357 0.342-0.380
Dakahlia	0.336	0.330	0.340	0.360	0.352	0.363	0.362	0.342	0.356	0.350	0.346	0.333	0.348 0.330-0.366
Alexandria	0.346	0.350	0.352	0.360	0.366	0.355	0.370	0.340	0.365	0.340	0.356	0.345	0.354 0.340-0.370
Ismailia	0.375	0.362	0.352	0.386	0.375	0.380	0.366	0.390	0.382	0.380	0.369	0.375	0.375 0.352-0.390
Suez	0.365	0.379	0.373	0.352	0.365	0.370	0.356	0.362	0.380	0.383	0.385	0.380	0.371 0.352-0.385
Port - Said	0.360	0.383	0.376	0.382	0.379	0.368	0.382	0.373	0.388	0.366	0.385	0.376	0.377 0.360-0.385

consumed daily, Stephen et al. (1988). The daily consumption of drinking water ranged from 3188 ml and 3375 ml for adults. The rate of consumption of fluoride from water was therefore calculated and ranged 1.147 to 1.215 mg daily. Accordingly, The fluoride supplement from drinking water should be 1.0 - 1.5 / mg F/ day (WHO, 1984).

B- Dietary intake of fluoride from diet and drinking water

By comparing the results of the fluoride intake in Egypt with the study presented by WHO 1984, it was found that the intake was 0.580 mg / person / day, whereas, the intake in the study of the WHO 1984 was 0.344 mg / person / day.

The difference between the two estimates is largely accounted for by the average consumption in Egypt for certain food groups is too high.

The largest contribution comes from the bread and cereals group which account for 64.48 % of the total followed by fish group (15.51%). The oils, fats, eggs and dairy products group account for 12.06%, whilst the other food groups contributed 7.95% of the total intake. The fluoride intake from drinking water in Egypt is estimated to be 1,147 – 1.215 mg / day, while the intake from tap water ranged from 1.0 to 1.5 mg / person / day (WHO, 1984).

By calculation the total fluoride intake presented by World Health Organization 1984 from diet and drinking water vary from 1.344 to 1.844 mg / person / day, whereas, the present study found that the total fluoride intake by the Egyptian citizen in Egypt ranged from 1.727 to 1.795 mg / person/ day.

As a result, the total fluoride intake from the diet and drinking water in Egypt falls within the safely recommended international limit.

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تقدير الاحتياج اليومي من الفلورايد من الغذاء ومياه الشرب في مصر زينب خليل العوامري المعمل المركزي للأغذية والأعلاف - مركز البحوث الزراعية - الجيزة - مصر

استهدفت الدراسة تقدير المأخوذ الكلي من الفلورايد في اليوم للمواطن المصري في الغذاء ومياه الشرب في مصر لمعرفة تأثير هذا المستوى على الصحة العامة ومقارنته بالحد المسموح به عالمياً. تم تقدير الاحتياج اليومي من الفلورايد في الغذاء باستخدام طريقة (Total Diet Study) حيث تم شراء وتجسيهز الاغذية المطبوخة شائعة الاستخدام وهذه المجموعات لا تحتوي على اغذية مستهلكه من خارج المنزل فقد تم نمج هذه الاغذية في اثني عشر مجموعة وكل مجموعة تشمل نوعية متشابهة من الغذاء وهي كالتالي :- الخبز والبقوليات - الدواجن - اللحوم ومنتجاتها - الاسماك - الزيوت والدهون والبيض ومنتجات الالبان - السكريات - الخضروات - البطاطس - الخضروات المطبوخة - الفواكه الطازجة ومنتجاتها - المشروبات وأخيراً الالبان وقد تم جمع ٣٠ عينة من كل مجموعة من الاثني عشر المجموعة السابقة شهرياً والتي تستهلك في المنازل من ثلاث محافظات القاهرة والجيزة والقليوبية خلال عام ٢٠٠٣ وقد تم تقدير الفلورايد في كل مجموعة وتم حساب متوسط المأخوذ الكلي من الفلورايد (ملجم / شخص / يوم) في مختلف مجموعات الاغذية الاثني عشر السابقة وكانت النتائج كالتالي :- ٣٧٤ و - ٠٠٥ و - ٠٠٩ و - ٠٠٧ و - ٠٠١ و - ٠١٩ و - ٠٠٧ و - ٠٠٧ و - ٠٠١ و - ٠٠١٧ و (ملجم / شخص / يوم) على التوالي وبالتالي يكون المأخوذ الكلي من الفلورايد للمواطن المصري يومياً من الغذاء ٥٨ (ملجم / شخص / يوم). تم تجميع عينات مياه شرب من عشر محافظات من جمهورية مصر العربية كان محتوى مياه الشرب من الفلورايد (مصدرها نهر النيل) يتراوح ٣٢٠ و - ٣٧٧ و ملجم / لتر بمتوسط ٣٦ و ملجم / لتر وتتراوح كمية المياه التي يستهلكها المواطن المصري ٣١٨٨ - ٣٣٧٥ مللي / يوم للكبار وبالتالي يكون المأخوذ من الفلورايد من مياه الشرب يتراوح ١٠٤٧ و - ١٢١٥ و ملجم / يوم. وبمقارنة نتائج المأخوذ الكلي من الفلورايد في مصر للمواطن المصري بما وضعته منظمه الصحة العالمية سنة ١٩٨٤ وجد أنه بالنسبة للغذاء فإن المأخوذ للشخص المصري ٥٨ ملجم / شخص / يوم في حين أن المأخوذ العالمي من الغذاء ٣٤٤ و ملجم / شخص / يوم. وبالنسبة لمياه الشرب فقد حددت منظمة الصحة العالمية الحد الامن المسموح به ١ و ملجم / شخص / يوم وقد وجد بالدراسة الحالية أن المأخوذ اليومي من الفلورايد من مياه الشرب في مصر يتراوح بين ١٠٤٧ و - ١٢١٥ و ملجم / شخص / يوم. وبحساب المأخوذ الكلي من الفلورايد الذي حددته منظمة الصحة العالمية من الغذاء والمياه يتراوح من ٣٤٤ و - ١٨٤٤ و ملجم / شخص / يوم بينما وجد بالدراسة الحالية أن المأخوذ الكلي من الفلورايد للمواطن المصري في مصر يتراوح من ٧٢٧ و - ١٧٩٥ و ملجم / شخص / يوم وبالتالي يكون المأخوذ الكلي من الفلورايد في مصر للمواطن المصري من الغذاء ومياه الشرب يقع في الحدود الآمنة المسموح بها عالمياً.