

Assessment of fluoride daily intake from water and tea infusions in endemic Ouargla, Algeria.

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Summary

In Algerian Sahara, tea consumption is well established in the local communities. 36 tea infusions were obtained from different specialized stores in Ouargla, Algeria. Fluoride was measured using the Alizarin spectrophotometric method. The fluoride Hazard Quotient (HQ), the Estimated Daily intake (EDI), and effect of brewing time on fluoride release were calculated. Using the value of 0.08 mg/kg/day as acceptable Reference Daily Intake, as recommended by EPA, it is estimated that consumption of respectively 1 and 4 cups of tea per day would give a Median Hazard Quotient HQ of 0.35 and 0.45. Thus, the EPA Hazard Assessment, fails to identify a significant hazard in these consumptions. However, the tea use on a daily basis is likely a significant source of fluoride in Ouargla city. The median level was 2.49 mg/L, and a wide range was found [0.75 to 5.85 mg/L]. The World Health Organization's current drinking water guideline (1.5mg/L) was surpassed by 75% of infusions tested. For heavy tea users who consume more than four cups of tea daily (1 L), the daily fluoride consumption from tea can range between 13.4 and 104.5% of the fluoride guideline daily dose. This study shows that the release of fluoride increases during the brewing process of 10 to 30 minutes and that black tea would contain double as much as the green teas at a 10 min brewing time.

Keywords: Tea; Fluoride; Risk assessment; Algeria; Africa.

1. Introduction

Fluoride is an interesting ion for preventing dental caries, and teeth upholding when used topically or ingested in amounts of about 0.05–0.07mg/kg body weight per day

[1]. However, prolonged exposure can result in dental and skeletal fluorosis, which is characterized by tooth mottling and skeletal symptoms [2-5]. Fluoride is primarily consumed by humans through drinking water [6,7]. However, this ion is also present in various concentrations in plants, animals, and foodstuffs [8-10].

Besides its particular taste, tea [*Camellia sinensis*] is described as being therapeutic and one of the oldest and most widely consumed non-alcoholic beverages [11-13]. However, tea is a fluoride-bioconcentrating plant, and has been reported to constitute a significant amount of fluoride is released during tea infusion [14-18]. Several studies have indicated that long-term tea drinking might cause dental fluorosis in various endemic areas, and, consequently, tea consumption is advised to be moderated [16, 19-22].

Tea is the classic Saharan hot beverage, readily adopted by the desert's nomadic peoples [23]. The Tuaregs have made the tasting of tea a real art, called "the ceremony of three teas", where tea is poured into three glasses, drunk very hot, in small sips (Figure 1).

Thus, in Saharan of Algeria, Africa, tea consumption is well established in the local communities, like in Ouargla city. Tea is everywhere, with the growing number of small stores specializing in the preparation and sale of this drink.



Figure 1. tradition of the three cups of tea in Sahara.

A Previous study performed in this city revealed that fluoride concentration in water ranged from 0.14 to 1.63mg/L, with the highest values in the rural areas [24]. Considering that in Ouargla city, drinking water is naturally rich in fluoride, and

drinking tea is a well-established habit, it is important to assess the safety of the exposure of humans to fluoride intake through tea consumption. Therefore, this study aimed to estimate the fluoride exposure through tea consumption and the effect of brewing time on fluoride release.

2. Materials and Methods:

2.1. Tea infusion samples

By 2021, a total of 36 different tea infusions sold in several stores in Ouargla city were purchased and analyzed to determine fluoride concentration. Samples were coded and analyzed directly.

Fluoride concentration in samples was determined using Alizarin complexone method [25] and assessed by an Agilent Cary100 Spectrophotometer. All reagents were analytical grade: Alizarin (97%, Sigma-Aldrich), Lanthanum (III) nitrate hexahydrate (99%, Merck), Aceton (99%, Merck) and, Sodium fluoride (99%, Merck). The analytical method was calibrated in the range of 0.05-1.50mg/L. Higher concentrations outside this range were diluted and measured.

2.3. Health risk assessment of fluoride

The assessment of the health risks associated with exposure to fluoride through the consumption of tea infusion was carried out using the US-EPA (United States-Environmental Protection Agency) method, which considers hazard quotient (HQ) as a ratio of the estimated dose of a contaminant to the reference dose [26].

For the health risk assessment, it is essential first to calculate the estimated daily intake (EDI) of tea ingestion by following the generic equation (Eq. 1):

$$EDI = \frac{C \times IR}{BW} \text{ (Eq. 1) [26].}$$

EDI is the estimated daily intake ($\mu\text{g}/\text{kg}/\text{day}$); IR is the intake rate of tea (L/day) that was; BW is the body weight (kg); C is the concentration of fluoride ($\mu\text{g}/\text{L}$).

The HQ is defined as the ratio of the estimated dose of a contaminant to the reference dose (Eq. 2).

$$HQ = \frac{EDI}{RfD} \text{ (Eq. 2) [26].}$$

Where reference dose (RfD) estimates daily exposure that is expected to be without significant risk of adverse effects during the lifetime of exposure, the Office of Water dose-response document for fluoride developed an estimated RfD of 0.08 mg/kg/day for the protection of 99.5% of the vulnerable population against severe

dental fluorosis and concluded that this value is also protective against fractures and skeletal effects in adults. If the HQ is greater than 100%, the estimated potential exposure exceeds the acceptable level, and the risk of severe fluorosis may be present.

2.3. Effect of time brewing in the release of fluoride

The fluoride content was analyzed in three imported brands: one black and two green teas. Infusions were prepared using 2 g of tea leaves with 100ml of deionized water. The tea extract was collected after 5, 10, 15, 20, 25, and 30min of brewing to check the influence of brewing time on fluoride content in water extracts.

2.4. Statistical analysis

Data were extracted to an Excel sheet and statistically analyzed to recognize trends of fluoride levels using IBM SPSS software version 23. A descriptive analysis based on average and standard deviation was carried out.

3. Results and discussion

3.1. Fluoride concentration in tea infusion and health risk assessment

Table 1 shows fluoride level for the 36 tea samples. The content of fluoride in tea beverages ranged from 0.75 to 5.85 mg/L.

Table 1. Mean and Median of measured fluoride concentrations in 36 tea samples and corresponding Estimated Daily Intake and Hazard Quotient at 1 and 4 cups by children and adults.

1 cup=250 mL n=36	Fluoride Conc in Tea mgF/L	EDI mg/kg/day				HQ	
		Adult 1 cup	Children 1 cup	Adult 4 cups	Children 4 cups	Children 1 cup	Adults 4 cups
min	0.75	2.68	9.38	10.7	0.03	0.117	0.13
max	5.85	20.89	73.13	83.5	0.26	0.914	1.04
Median	2.49	8.90	31.13	35.57	0.11	0.39	0.45
SD ±	1.25	4.47	15.65	17.89	0.06	0.20	0.22
Mean	2.31	8.24	28.84	32.96	0.10	0.36	0.41

Fluoride can be found in a variety of foods, including vegetables, fruit, tea, and other products, although drinking water is the most common source [27]. The obtained concentrations are comparable with those reported by other authors and show that fluoride is present in tea with different concentration [14, 28-30].

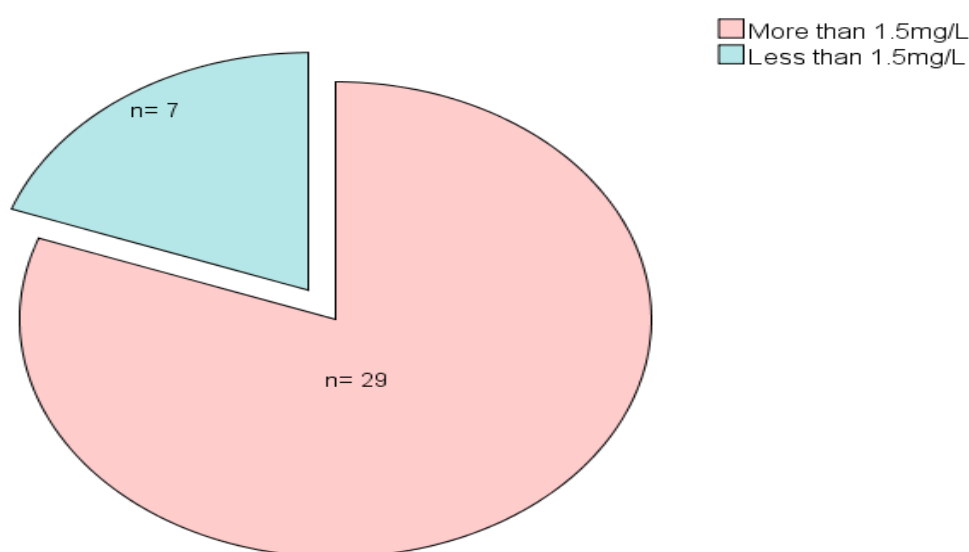


Figure 2. Fluoride level in tea infusion (n=36).

The World Health Organization's current drinking water guideline (1.5mg/L) was surpassed by 80.6% of the teas tested (Figure 2). Tea consumption, therefore, seems to represent a major dietary source of fluoride intake. However, the results could be linked to significant levels of variability, such as tea weight, brewing duration, and water used during preparation. It is also possible that the provenance of tea may change over time, and that the quality of the product may alter depending on where it is grown.

A dose of 0.08mg/kg/day has been established as the benchmark level. One cup of tea (250mL) with 0.75mg/L fluoride concentration represents 11.7% fluoride intake in children, and 3.3% for adults, while one cup with the highest fluoride

concentration (5.85mg/L) represents 91.4% fluoride intake in children and 26.1% for adults.

Dental fluorosis among children has been linked to increased consumption of tea [31, 32]. This raises concerns regarding the safety of tea consumption in children, as they are also exposed to additional sources of fluoride, such as toothpaste, which can result in an excessive daily fluoride intake [33]. Therefore, it is critical to establish limits for tea intake, particularly in children, and to be aware of other possible sources of environmental fluoride, particularly in fluoride-rich locations.

For heavy tea users who consume more than four cups of tea daily (1 L), safety concerns arise since the daily fluoride consumption from tea can range between 13.4 and 104.5 % of the guideline daily dose in adults (Table 1).

Therefore, in regions where tea consumption is widespread, such as Ouargla city, where fluoride levels in the drinking water are moderate to high [24], the infusion should be prepared using low-fluoride bottled water or water that has been treated to remove fluoride.

Despite the increasing demand for tea in recent years, there is currently no food safety regulation for fluoride in tea entering Algeria. As a result, there are no labeling rules for teas, and all grades are freely available on the market. Including the fluoride content on tea packet labels may be one way to educate both the customer and the infusion tea maker about the dangers of fluoride exposure.

3.2.Effect of brewing time on fluoride release

Figure 3 presents fluoride content in tea infusions dependent on the brewing time. The highest level was obtained for the infusion of black tea and the lowest one was found in extract of green tea.

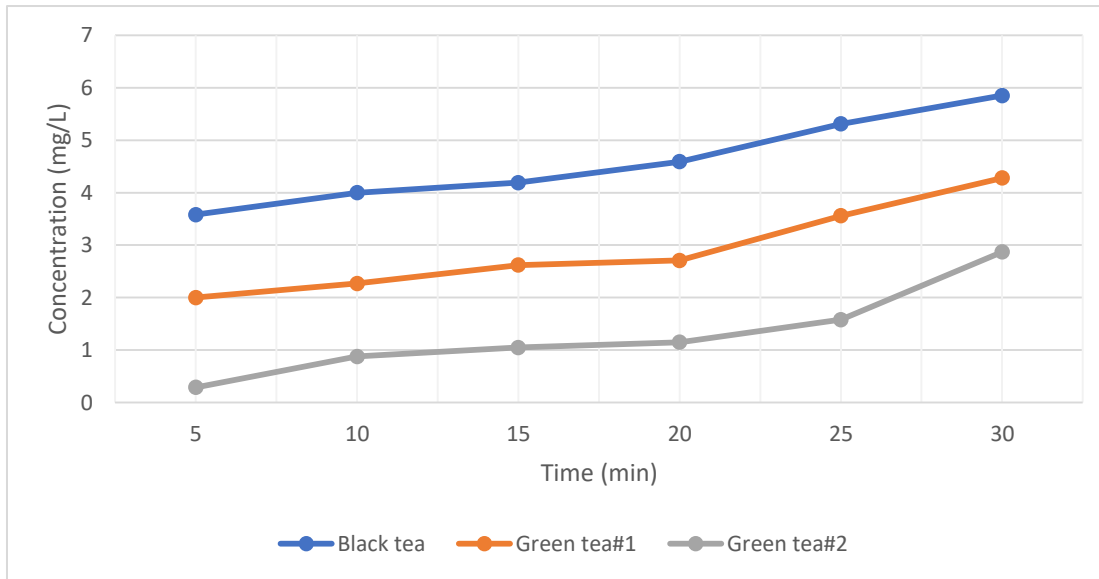


Figure 3. Effect of time on fluoride release from tea.

The amount of fluoride in the examined extracts increased after 10-, 15-, 25-, 25- and 30-min brewing than after 5 min. A positive association was found between fluoride concentration in the infusion and the brewing time, regardless of the tea brand. Malinowska et al. [28] also found that brewing time increases the fluoride content in tea beverages. The increase of fluoride content released into black tea infusion after 10 min of brewing was 11.7% and 63% after 30 min. In the green tea infusions, the increase of fluoride content after 10 min of brewing ranged from 13.0% to 300%, while after 30 min, this was from 200% to 989%.

Due to the fact that the manner of brewing the tea was standardized, the significant variances observed are most likely due to manufacturing methods and origins. Thus, the fluoride level of teas is expected to be affected by the type and grade, relative composition, and particle size of the teas [28].

4. Limitations

Some limitations are to be noted for this work; number of samples is small, and a larger study area should also be proposed to get an idea of the whole of the country's south profile.

5. Conclusion

Tea use on a daily basis is likely a significant source of fluoride in southern Algeria. While fluoride in drinking water is below WHO guideline, tea infusions available in this city surpass the current limit of 1.5 mg/L. Thus, a heavy tea drinker's fluoride intake might rapidly surpass permissible levels, posing a risk of dental fluorosis.

Certain teas contain significant quantities of fluoride, while others contain far less. Brewing time has an effect on the amount of fluoride released during infusion and should be checked to less than 10 min in order to minimise exposure to F. Our study provides an initial estimate of the fluoride concentration in tea infusions and paves the way for more accurate monitoring in order to avoid adverse effects on sensitive populations.

Conflicts of interest

The authors of this article declare that they have no conflict of interest.

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Author contributions

MA. Kerdoun: Conceptualization, Methodology, Writing, Reviewing. **S. Mekhloufi:** Sample collection, Analysis. **OE. Adjaine:** Sample collection, Analysis. **Z. Bechki:** Analysis. **RM. Kerdoun:** Reviewing **H. Dali:** Analytical support, **S.Mouffok:** Analytical support.

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