

# Fluoride content in various types of tea used by tea stalls in Salem district – An *in vitro* cross sectional study

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## Abstract

**Background:** Tea leaves are natural rich source of fluoride and are known as fluorine absorbants. It is consumed on large scale in India and thus needs to be monitored for its daily fluoride consumption by customers. Tea manufacturers should mention fluoride concentrations on the packages to avoid overdose through unknown consumption by consumers.

**Objectives:** To detect the levels of fluoride in tea at different periods of boiling and to compare the fluoride levels in various brands of tea at different periods of boiling.

**Methodology:** A survey was conducted in 25 tea stalls of Salem on the type of tea and time of boiling black tea. The five most common brands of tea will bought for the study. The stainless-steel vessel will be used in the methodology for boiling tea. Mettur water will be used for the preparation of black tea and 1 g of tea leaves to 100 ml of hot (~95°C) deionized water (1% w/v tea infusion) and allowed the mixture to stand for 5 min in a glass beaker. After 5 min, the infusions were filtered and again left standing until they are cooled to room temperature. All fluoride measurements will be completed within 4 h of the preparation of the infusion. About 2 min and 4 min boiling will be followed. The fluoride present in each brand of tea will be calculated from black tea prepared using 2-(parasulfophenylazo)-1,8-dihydroxy-3,6-naphthalene-disulfonate (SPADNS) calorimetric method.

**Results:** The distribution of mean score of fluoride level in tea powders available in tea shops of Salem when boiled in distilled water was (559.00 ± 112.12). The mean score of fluoride level in tea powders available in tea shops of Salem boiled in Mettur water was (689.05 ± 116.34). To test the significance of difference between the average fluoride in tea powders available in tea shops of Salem when boiled in distilled water and Mettur water, the independent *t*-test was used. the *P* value is <0.05, and hence, it is found that there is significant difference between the average fluoride in tea powders available in tea shops of Salem boiled in distilled water and Mettur water.

**Conclusion:** Thus, the study showed tea consists of significant amount of fluoride concentration that is consumed on daily basis. The study also evaluated fluoride concentration in tea preparations using different water. The study shows necessity for regulations of mentioning fluoride concentration on tea packs.

**Keywords:** Dental caries, fluoride, fluorosis, prevention, tea

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## INTRODUCTION

Fluoride, an ionic form of mineral fluorine is found abundantly in nature including soil, water, air, plants and animals. The average fluoride content in soil ranges from about 100–600 mg/kg, of which about 0.05%–0.5% are water soluble fluorides. Water is the major source of fluoride; however, it varies in concentration based on its geographical locations of the water bodies. Fluoride is also released in air and present in concentration of <1 µg/m. Other sources of fluoride include tea, medicines, and fluoride-induced toothpastes. About 99% of body fluoride is found on bones and teeth. It does not have any specific function in human growth or functioning. Fluoride is found to increase osteoblastic activity in bones. However, fluorides in teeth are well known for caries prevention by replacing hydroxyapatite crystals to form fluorapatite crystals. Optimal intake concentration is necessary for its action in prevention of dental caries. Inadequate fluoride content can cause increase in caries and its rise in its consumption may cause dental fluorosis resulting in defective teeth in children and skeletal fluorosis in adults to cause bone and joint symptom. The “optimal” (or “adequate”) daily intake of fluoride for children is between 0.05 and 0.07 mg/kg body weight. Fluoride levels recommended in temperate region is of 0.5 ppm since more water is consumed and levels recommended as high as optimum is 1.5 ppm in cold climate where less water is consumed. However, on an average, the optimum fluoride level in drinking water is calibrated at 1 ppm worldwide (0.7–1.2 ppm). Due to its caries prevention activity, it has led to addition of fluorides in toothpastes, milk, salt and water in desired proportions. School water fluoridation programs are being conducted in areas with lack of fluoride intake in general. The fluoride concentrations added in these programs is 4.5 to 5.5 ppm. The school water fluoridation program helps to benefit the children prone to more caries activity. Other methods for systemic fluoridation include salt fluoridation, milk fluoridation, flour fluoridation, fluoride supplements—tablets, drops and lozenges. Topical fluoridation includes tooth dentrifices, fluoride rinse, fluoride dentrifices, fluoride toothpastes, varnishes, gels and foam infused with fluoride advised in children to for caries prevention in children.<sup>[1-4]</sup>

Excess amounts of total fluoride intake may cause dental fluorosis and skeletal fluorosis. Endemic fluorosis is known in India since 1937 that results due to high amounts of fluoride concentration in water.<sup>[1,4]</sup>

Tea, extracted from the leaves of plant *Camellia sinensis* is one of the rich sources of fluorides. It is known as major fluorine accumulator as it absorbs greatest amounts of

fluorines and its leaves consists of largest amounts of fluoride content. Tea also known as chai is consumed on large scale in India on daily basis. Correlation between tea and fluorosis is mentioned in the literature and its daily intake alone crosses the adequate fluoride intake that may cause dental and skeletal fluorosis.<sup>[1,4,5]</sup> Several companies do not provide the detailed data about its fluoride content and thus monitoring the fluoride content in tea becomes necessary. Thus, present study was conducted to evaluate the fluoride content in various commercial brands of tea available in markets of Salem.

The aim of this study is to estimate the fluoride content in various popular tea brands used by tea stalls in Salem city at different periods of boiling using Mettur water.

Objectives of the study included detecting the levels of fluoride in tea at different periods of boiling and to compare the fluoride levels in various brands of tea at different periods of boiling.

## METHODOLOGY

A survey was conducted in 25 tea stalls of Salem on the type of tea and time of boiling black tea. The five most common brands of tea were bought for the study. Tea powder brands commonly used by tea stalls of Salem were used in the study and other tea samples outside Salem district were excluded.

### Ethical clearance

Ethical clearance was obtained from institutional research and ethics committee.

### Sample preparation and analysis

The stainless-steel vessel was used in the methodology for boiling tea. Mettur water was be used for the preparation of black tea and 1 g of tea leaves to 100 mL of hot (~ 95°C) deionized water (1% w/v tea infusion) and allowed the mixture to stand for 5 min in a glass beaker. After 5 min, the infusions were filtered and again left standing until they were cooled to room temperature. All fluoride measurements were completed within 4 h of the preparation of the infusion. 2 min and 4 min boiling were followed. The fluoride present in each brand of tea will be calculated from black tea prepared using SPADNS (calorimetric method). This method relies on the fact that when fluoride reacts with certain zirconium dyes, a colorless complex anion and a dye are formed. The complex, which is proportional to the fluoride concentration, tends to bleach the dye which therefore becomes progressively lighter as the fluoride concentration increases. In the case

of the fluoride ion reaction with Zr-SPADNS [sodium 2-(parasulphophenylazo)-1,8-dihydroxy-3,6-naphthalene disulphonate], the resulting coloured complex is measured in a spectrophotometer at 570 nm.

Statistical analysis was done by entering data in SPSS software. Fluoride level was calculated for each tea brand by boiling it both in distilled water and Mettur water. The mean fluoride levels were calculated separately for boiling distilled water and Mettur and compared by student *t*-test.

## RESULTS

Fluoride concentration was calculated separately by boiling in distilled water and Mettur water for comparison of Fluoride release between the two.

In distilled water boiling, sample 10 showed maximum fluoride release and Sample 6 showed the least release. In Mettur water boiling, sample 5 showed highest fluoride release while sample 3 showed the least release. Mean was calculated for samples boiled in both waters and was compared using independent *t*-test.

The distribution of mean score of fluoride level in tea powders available in tea shops of Salem when boiled in distilled water was (559.00 ± 112.12) [Table 1]. The mean score of fluoride level in tea powders available in tea shops of Salem boiled in Mettur water was (689.05 ± 116.34) [Table 2]. To test the significance of difference between the average fluoride in tea powders available in tea shops of Salem when boiled in distilled water and Mettur water, the independent *t*-test was used and the result is also given in the following Table 3.

The result shows that the *P* value is <0.05 and it is found that there is significant difference between the average fluoride in tea powders available in tea shops of Salem boiled in distilled water and Mettur water. Thus, the study shows, the fluoride level of tea powders used in tea stalls of Salem is high when boiled in Mettur water than in distilled water [Graph 1].

## DISCUSSION

Fluoride is recognized in abundant proportions in nature and can be administered in the human body through air, water and foods. Optimal amount of fluoride intake is found to be effective for caries prevention. Fluoride prevents caries formation at about 1 mg/L of dosage but it may cause dental fluorosis causing mottled teeth and skeletal fluorosis resulting in bone damage at over 5 mg/L of fluoride doses for prolonged time period. Predominant

**Table 1: Comparison of fluoride levels in 10 different samples of tea powders when boiled in distilled water**

| Tea powder names | Results–distilled water |
|------------------|-------------------------|
| Sample 6         | 364 mg/L                |
| Sample 4         | 524 mg/L                |
| Sample 2         | 554 mg/L                |
| Sample 8         | 588 mg/L                |
| Sample 3         | 599 mg/L                |
| Sample 7         | 599 mg/L                |
| Sample 9         | 632.5 mg/L              |
| Sample 1         | 644 mg/L                |
| Sample 5         | 644.5 mg/L              |
| Sample 10        | 658.5 mg/L              |

| Results–distilled water | Samples | Fluoride level |
|-------------------------|---------|----------------|
| 300–400 mg/l            | 1       | Low            |
| 500–600 mg/L            | 5       | Medium         |
| 600–700 mg/L            | 4       | High           |

**Table 2: Comparison of fluoride levels in ten different samples of tea powders when boiled in Mettur water**

| Tea powder names | Results – Mettur water |
|------------------|------------------------|
| Sample 3         | 575 mg/L               |
| Sample 6         | 578 mg/L               |
| Sample 4         | 584 mg/L               |
| Sample 7         | 587 mg/L               |
| Sample 8         | 635.5 mg/L             |
| Sample 9         | 642.5 mg/L             |
| Sample 10        | 645.5 mg/L             |
| Sample 1         | 673 mg/L               |
| Sample 2         | 737 mg/L               |
| Sample 5         | 950 mg/L               |

| Results–Mettur water | Samples | Fluoride level |
|----------------------|---------|----------------|
| 500–600 mg/l         | 4       | Low            |
| 600–700 mg/L         | 4       | Medium         |
| 700–800 mg/L         | 1       | High           |
| 900–1000 mg/L        | 1       |                |

**Table 3: Fluoride level of tea powders boiled in distilled water and Mettur water**

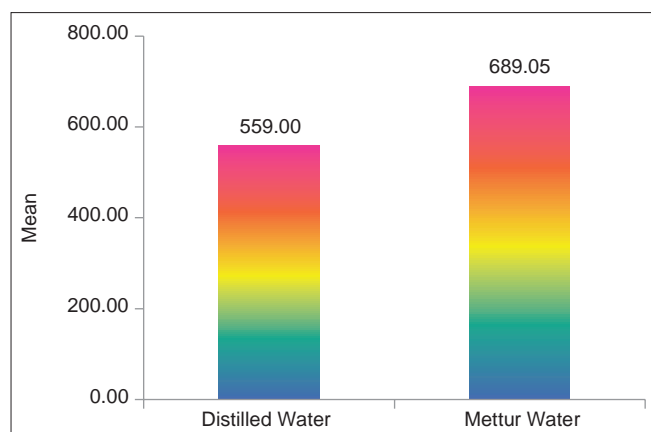
|                 | <i>n</i> | Mean   | SD     | SE    | <i>t</i> | <i>P</i> |
|-----------------|----------|--------|--------|-------|----------|----------|
| Distilled water | 10       | 559.00 | 112.12 | 35.46 | 2.545    | 0.020*   |
| Mettur water    | 10       | 689.05 | 116.34 | 36.79 |          |          |

\*Significant at *P* value < 0.05

source of fluoride includes water. However, in recent times, fluoride is infused in products such as medicines for its beneficial effects in diseases such as osteoporosis, ischemia, etc., and toothpastes for its preventive effects in dental caries.<sup>[6]</sup>

It is well proved that fluoride has preventive effect in decay at 1 mg/L but has adverse effects at concentration of 5 mg/L over long period of time. As a fluorine absorbant, tea leaves act as a major source of daily intake. Being a widely consumed beverage, it is necessary to monitor the fluoride content and intake of tea.<sup>[5,6]</sup>

In the current study, fluoride concentration varied from 364 to 658.5 mg/L when boiled in distilled water and 575 to 950 mg/L when boiled in Mettur water. The study showed



**Graph 1:** Fluoride level

clear difference between fluoride release from tea when boiled in distilled water and Mettur water. Sample 6 and sample 10 showed least and highest fluoride release when boiled in distilled water, respectively. However sample 3 and sample 5 showed least and highest fluorides release when boiled in Mettur water, respectively.

To confirm the difference in fluoride release when boiled in distilled water and Mettur water, student *t*-test was carried out for the same. The mean of fluoride levels in tea brands found in Salem boiled in distilled water was  $(559.00 \pm 112.12)$  and that boiled in Mettur water was  $(689.05 \pm 116.34)$ . The independent *t*-test showed a clearly significant difference ( $<0.05$ ) between the fluoride release of tea boiled in distilled water and Mettur water.

A study by MDC Audrey and Shankar Aradhya, 2012, showed fluoride content in tea infusions increased with increase in brewing time.<sup>[7]</sup> A study carried out by Gupta and Sandesh in 2012, estimated fluoride content of various tea brands in Mathura city. The study evaluated fluoride concentration by three different methods that is without boiling with water, after boiling with water and after addition of milk and sugar to boiling water. The mean fluoride concentration in tea infusions by three methods were 1.437, 3.375, and 3.437, respectively. The study shows fluoride content of tea can be additional dietary source of fluoride.<sup>[8]</sup> A study by Validandi V *et al.*<sup>[9]</sup> in 2019 evaluated tea to deliver about 0.03 to 0.14 mg/Kg fluoride in children and 0.01 to 0.06 mg/Kg in adults. The study conducted by Nattha Pattaravitsate *et al.*<sup>[10]</sup> aimed to investigate the concentrations of infusible fluoride in five different types of tea and herbal products; additionally, the probabilistic health risks associated with the ingestion of fluoride in drinking tea and herbal products were estimated. The highest and lowest concentrations of infusible fluoride were detected in black and white tea, respectively. On average, the highest

amount of infusible fluoride was extracted following a short brewing time of 5 min in the case of black tea (2.54 mg/L), herbal tea (0.40 mg/L), and white tea (0.21 mg/L). A study was conducted by Nimisha Krishnankutty *et al.*<sup>[11]</sup> to evaluate maternal exposure to fluoride through tea consumption in a low-fluoride region and measured fluoride releases from commercially available teas (tea bags and loose teas) to determine the need to limit fluoride exposure. The study determined fluoride exposure among pregnant women increases with tea consumption, with likely risks of developmental neurotoxicity to their children thus proving the need for mentioning fluoride content in tea. Ryouichi Satou *et al.*<sup>[12]</sup> conducted a study to estimate the daily fluoride intake from preference beverages by measuring the fluoride concentration of infusion liquid and measuring the total fluoride content by the microdiffusion method. In the study, tea was the highest in all sample species, the infusion of tea was 1.06–6.68 mg/L and the total fluoride content of tea was 47.05–291.98 mg/kg that was the highest. Nagarajuna *et al.* in 2018 showed concentration of fluoride varied in tea with increase in brewing time, concentration of fluoride in water used and addition of sugar and milk. The present study showed similar results as the study by Nagarajuna *et al.*, the fluoride concentration of tea varies when boiled in distilled water and Mettur water. These results depend on fluoride content of water used to boil. Thus, general population tea manufacturers and clinicians should be aware about the fluoride content of tea and its daily consumption. Since large amount of fluoride intake has deleterious effects on bones and teeth it is necessary to monitor daily fluoride intake through tea in addition to water and other fluoride containing products. Various brands contain different concentration of fluoride in them and many brands don't mention fluoride concentration on the package and in turn general public remains unaware about their daily fluoride intake. Thus, manufacturers and clinical practitioners must take fluoride concentration tea daily consumed into consideration to supervise fluoride intake of individuals.

## CONCLUSIONS

Tea is consumed in large amounts in India. However, tea is known to be highly rich in its fluoride content but is not mentioned on the packages supplied. Fluoride in large amounts may cause dental and skeletal fluorosis and thus daily intake needs to be monitored. The present study shows the fluoride content of each brand varies. Also, fluoride content of prepared tea depends on the water content of fluoride that is used. Thus, brands should be imposed with strict rules to mention details on its fluoride content that customers may choose accordingly.

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### Conflicts of interest

There are no conflicts of interest.

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