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Effect of boiling and storage in five different commonly used cooking vessels on water fluoride concentration

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ABSTRACT

To evaluate the effect of cooking vessel composition on the concentration of fluoride in the water used for cooking and also its effect on fluoride levels after storage for 24 hours. Standard water sample of 1parts per million (ppm) fluoride concentrations was boiled in five commonly used cooking vessels in India namely Aluminium, Earthen pot, Stainless Steel, Teflon and Glass. The fluoride levels in water were analyzed two hours after boiling and after storage for 24 hours using Ion Chromatography method. The data was analyzed using Mann Whitney U and Kruskal Wallis test. There was an increase in fluoride concentration in water boiled in Teflon (1.36 ppm), Stainless Steel vessels (1.06ppm) whereas a decrease was observed in Aluminum (0.76ppm), Earthen Pot (0.85ppm) and Glass vessels (0.98 ppm). After 24 hours storage there was a further drop in fluoride concentration in water stored in Aluminum (0.74ppm) and Earthen pot (0.82ppm), while there was an increase in fluoride concentration in water stored in Teflon vessel (1.39 ppm). There was a statistically significant difference in fluoride concentration in water boiled in five different vessels, analyzed 2 hours after boiling and after storing for 24 hours (P= 0.009). Fluoride concentration in water boiled in Stainless Steel and Teflon vessels increased, whereas a decrease was observed in Aluminum, Earthen pot and Glass vessels. Further research to assess the effect of cooking vessel composition on the fluoride concentration in water and food prepared is needed.

Key words: Cooking vessels, Fluoride concentration, Boiling, Storage.

INTRODUCTION

Prevention is better than cure goes the old maxim. Research on the oral health effects of fluoride started way back in 1930; from then on, the focus of research was on the consequential effects of various fluoride delivery systems, on prevention of dental caries [1]. Extensive databases generated through systematic reviews, have led to the conclusion that water fluoridation, and the use of fluoride tooth paste and mouth rinses have significantly contributed towards prevention of dental caries [1].

While other fluoride-containing products are available, water fluoridation remains the single most cost effective method of delivering fluoride to all communities starved of optimum level of fluoride in water. Fluoride was first added to Grand Rapids water supply in 1945. The Center for Disease Control and Prevention has ranked water fluoridation as one of the ten great public health achievements of the 20 th century [2]. The Canadian Dental Association (CDA) encourages the appropriate use of fluorides in preventive dentistry to be the most successful preventive health measures in the history of health care [3].

The behavior of fluoride on humans is a double-edged sword, being vital for the prevention of dental caries, mitogenic stimulus for osteoblasts, and enhancement of mineral deposition while simultaneously proving to be toxic above a threshold concentration [4].

Fluorosis is an important public health problem in 24 countries, including India [5]. Of the 85 million tons of fluoride deposits on the earth's crust, 12 million are found in India leading to widespread, intensive and alarming contamination of ground water. Ground water being the main resource for the vast population of India, results in consumption of elevated levels of fluorides among the majority of people thus increasing their risk to develop fluorosis [5]. Reports on Endemic flurosis in India have been reported since 1937 .Seventeen of the thirty five states in India, where fluoride level in drinking water is greater than 1.5 mg/l are endemic for fluorosis resulting in about 25 million people suffering from dental, skeletal and non- skeletal fluorosis [6].

The omnipresence of fluoride in India makes it an inevitable component of human diet as the water from various ground sources is used for drinking and cooking.

Metals form insoluble compounds with fluoride [7]. Thus the material ingredients of cooking vessel and the resultant evaporation of water during the process of cooking may influence the concentration of fluoride in water and the food prepared. Full C.A. and Parkins F.M have reported variations in fluoride concentration of water boiled in vessels of different surface composition [7]. Shanon IL in his study has analyzed the changes in fluoride concentration in water boiled in Aluminium and Teflon vessels [8]. Hauges S et al have studied the effect of clay pots on the fluoride concentration in water [9].

The most commonly used vessels for cooking in India are Aluminium, Earthen Pot, Stainless Steel, Teflon and Glass. There are few studies conducted across the globe on the effect of boiling water on fluoride levels in different vessels; however there are no Indian studies on this issue. The aim of this study is to evaluate the effect of cooking vessel composition on the concentration of fluoride in the water used for cooking and also its effect on fluoride levels after storing it for 24 hours.

MATERIALS AND METHODS

Standard water sample of 1ppm fluoride concentrations was prepared from a 1000 ppm fluoride stock solution containing Sodium fluoride at Chennai Mettex Lab Private Limited. 5 liters of the standard water solution was utilized for the study. For the present study five commonly used cooking utensils were selected to find out the effect of the fluoride levels on boiling and storing water for 24 hours. All the cooking vessels were newly procured from a reputed super market and care was taken that the products were manufactured within 6 months of the initiation of the study. The vessels were used to boil water for five times before the initiation of the study.

The cooking utensils were grouped under the following:

Group 1(Aluminium) – The composition of the utensils consisted of an alloy of

a. Aluminium -98.3%
b. Iron -0.5%
c. Silicon -0.5%
d. Manganese -0.1%
e. Chromium -0.1%
f. Nickel-0.1%
g. Zinc-0.1%
h. Titanium -0.1%
i. Tin -0.1%
j. Copper -0.1%

Group 2(Earthen Pot) - Earthen pot made of Clay and red soil was used in the study

Group 3-(Stainless Steel) - The vessel used in the study had a composition of 18% Chromium and 8% Nickel.

Group 4-(Teflon)-Teflon vessel made of Stainless steel with a Poly Tetra Fluoro Ethylene coating was used to boil the water . The Stainless Steel vessel had a similar composition of 18% Chromium and 8% Nickel.

Group 5-(Glass)-The Glass vessel used to boil the water had a composition of

a. Silicon Oxide -80.62 %
b. Boric oxide -12.6%
c. Sodium oxide -4.2%
d. Aluminum oxide -2.2 %
e. Ferric oxide -0.04%
f. Calcium oxide -0.1%
g. Magnesium oxide -0.05 %
h. Chlorine -0.1 %

In each of the vessels 500 ml of water was taken, as a minimum of 200 ml of water was required to analyze the fluoride concentration in water. Hot plate manufactured by Bionic Scientific Technologies with a highest setting point of 250 degree Celsius was used to bring the water to rolling boil, after which the temperature was reduced to about 70 degrees to maintain a moderate degree of boiling for 15 minutes. The water was collected in a polyethylene bottle and was analyzed two hours later after the temperature had come down to room temperature. In order to determine the effect of storage, water samples were stored in the same vessel in which they were boiled and the fluoride levels were analyzed after 24 hours. This procedure was repeated thrice and the mean fluoride concentration was obtained.

The fluoride levels in the water samples were analyzed by Ion Chromatography method .The following apparatus were used for the analysis.

Ion Chromatograph: Dionex DX500
Columns: Dionex AG9-HC/AS9-HC, 2 mm
Detector: Suppressed Conductivity Detector, Dionex CD20
Suppressor: ASRS-I, external source electrolyte mode, 100mA current
Eluent: 9.0 mM Na_2CO_3
Eluent flow: 0.40 ml per minute
Sample loop: 10 µl
System backpressure: 2,800 psi
Background conductivity: 22 µS

This equipment has a precision of detecting fluoride levels from 0.26 to 8.49 ppm.

Descriptive statistics were calculated and expressed as mean and standard deviation. Mann Whitney U test was used to analyze the change in fluoride concentrations analyzed two hours after boiling and after storage for 24 hours. Kruskal Wallis test was used to analyze the difference in fluoride concentration in water boiled in five different vessels, analyzed 2 hours after boiling and after storage for 24 hours. The level of significance was set as 0.05 and P values less than 0.05 was considered statistically significant. The data was analyzed using Statistical Package for Social Sciences version 19 (IBM, 2010).

RESULTS

This present study was done to assess the changes in the mean fluoride concentration of water boiled in various types of cooking vessels analyzed two hours after boiling and after storage for 24 hours. Among the various vessels used in the present study, there was a significant increase in fluoride concentration of water boiled in Teflon vessels analyzed 2 hours after boiling (1.36ppm) and after storage for 24 hours (1.39 ppm). A significant drop in fluoride concentration was also observed in water boiled in Aluminium vessel analyzed two hours after boiling (0.76 ppm) and also on storage for 24 hours (0.74 ppm). A slight increase in fluoride concentration when water was boiled in Stainless Steel vessel was observed and the level remained the same for 24 hours (1.06 ppm).Water boiled in Earthen Pot showed a reduction from baseline values when analyzed two hours after boiling (0.85 ppm) and also after storage for 24 hours (0.82 ppm).Water boiled in Glass vessel showed a reduction from baseline when analyzed

two hours after boiling and remained the same after storage for 24 hours (0.98ppm). There was no statistically significant difference observed between the changes in fluoride concentrations analyzed two hours after boiling and after storage for 24 hours (P value>0.05). (Table 1)

Further, there was a statistically significant difference in fluoride concentration in water boiled in five different vessels, analyzed 2 hours after boiling and after storage for 24 hours (P value 0.009). On Individual comparison, a significant difference was observed between Glass and other vessels when the water was analyzed for Fluoride levels two hours after boiling (P value <0.05). However no statistically significant difference in fluoride concentration was observed when water was analyzed after the storage period of 24 hours. (P value >0.05)(Table 1)

DISCUSSION

Rocks rich in fluoride are the major source of fluoride in ground water [5]. India lies in the geographic fluoride belt extending from Turkey to China and Japan, through Iran, Iraq and Afghanistan. The rocks present at Nalgonda district of Andhra Pradesh, have a fluoride concentration of more than the world's average fluoride concentration of 810 mg/kg [5].Dental and skeletal flurosis are a major public health problem in various parts of Indian subcontinent due to the utilization of fluoride contaminated ground water. The Bureau of Indian Standards has therefore laid down the standards as 1.0 mg/l as maximum permissible limit of fluoride and further remarks that "lesser the better "[10].

Fluorine being the most electronegative element and a strong oxidizing agent reacts with metals. Thus the composition of the cooking vessels may have an effect on the fluoride concentration in water. With time and discovery, the conventional earthen vessels have been replaced by metal vessels such as Aluminum, Stainless Steel and Teflon vessels. Earthen vessels are widely used in rural areas unlike urban population where non stick cookware and Pyrex Glass are used.

Full CA and Parkins FM in their study analyzed the changes in fluoride concentration when tap water in a community with known fluoride concentration was boiled in Aluminium, Stainless Steel, Teflon and Glass vessels. The result showed that there was a decrease in fluoride concentration in water that was boiled in Aluminium vessel from 1ppm to 0.5 ppm and an increase in fluoride concentration in water that was boiled in Teflon vessel from 1ppm to 3ppm. A minor decrease in the fluoride concentration in water that was boiled in Glass vessel, and a minor increase in fluoride concentration in water that was boiled in Stainless Steel was also noted [6].

The fluoride concentration in the present study decreased from 1ppm to 0.76 ppm when analyzed 2 hours after boiling the water in Aluminium vessel and there was a further decrease to 0.74 ppm when the boiled water was stored in the Aluminium vessel for 24 hours. This was in accordance to the study done by Full CA and Parkins FM where there was a decrease in fluoride concentration in water boiled in Aluminium vessel [6]. Rao TVR et al in their study have reported that fluoride present in water used for cooking enhances the migration of aluminium from the vessel [11]. Tennakone K, Wickramannayake S and Fernando C.A.N have reported that trace amounts of fluoride in water and fluoride rich foodstuff can catalyze the dissolution of Aluminium from the vessel [12]. Poonam R et al have observed a small amount of leaching from Aluminium vessel during preparation of tea [13]. Thus the decrease in fluoride concentration in water boiled and stored in Aluminium could be due to the formation of metallic compounds as a result of interaction between the vessel surface and fluoride in water.

An increase in fluoride concentration from 1ppm to 1.36ppm was observed when analyzed 2 hours after boiling in Teflon vessel and there was a further increase to 1.39 ppm after 24 hours storage. Teflon vessels are made up of steel with a Poly Tetra Fluoro Ethylene (PTFA) coating which are responsible for the non stick nature of the vessel. Full CA and Parkins FM in their study reported that water boiled in Teflon vessel increased the concentration of fluoride from 1ppm to 3ppm, as there was no interaction between the vessel wall and water, and the increase in the fluoride concentration was due to the evaporation of water during boiling [6]. Shanon IL reported that Teflon vessels release small amount of fluoride while boiling water in them [7]. In the present study also there was an increase in fluoride concentration in water boiled and stored in Teflon vessel. The evaporation of water from the vessel could be a possible explanation for this phenomenon.

Fluoride concentration in water sample boiled in Stainless steel vessel increased from 1ppm to 1.06 ppm when analyzed 2 hours after boiling and there were no changes seen in the fluoride concentration when the boiled water was stored for 24 hours. This was similar to the study conducted by Full CA and Parkins FM [6].

In the water that was boiled in Glass vessel a decrease in fluoride concentration from 1ppm to 0.98 ppm was observed on analysis after 2 hours and there was no change in fluoride concentration when the boiled water was stored in the Glass vessel for 24 hours. This was in accordance to the study by Full CA and Parkins FM, who suggested that the mild decrease could be due to the interaction between the Glass vessel and the fluoride in water during boiling [6].

In the present study we observed that there was a decrease in fluoride concentration from 1 ppm to 0.85 ppm in water samples boiled in Earthen pot when analyzed 2 hours after boiling and there was a further decrease to 0.82 ppm when the water was stored for 24 hours. Hauges S et al in their study have reported that clay pots fired at a suitable temperature of 600 degree Celsius were effective in reducing the fluoride concentration [9]. The decrease in fluoride concentration can be attributed to the presence of red mud and clay which was used to prepare clay pots. Red mud is an industrial by product that is produced during the production of Aluminum. Othman OC et al have reported that red clay soil reduced the fluoride concentration from 4.59 ppm to less than 1.1 ppm [14]. Bjorvatn K and Bardsen A have demonstrated that the use of laterite soil reduced the fluoride concentration in water from 5.47 ppm to 0.48 ppm in 2 hours and from 12.2 ppm to 0.26 ppm in 12 hours [15] .The variations in the level of decrease in the fluoride concentration in the different studies may be due to the difference in the soil composition at different countries used for the production of Earthen pot.

To the best knowledge of the author , this study is one of the first study to be conducted in India, where the effect of the composition of various commonly used vessels, on the fluoride concentration in water have been studied, using a standard water sample of 1ppm . The water samples in this study were analyzed 2 hours after boiling as they had to be brought down to room temperature as analysis could not be done immediately after boiling. This study assessed the effect of storing water in the vessels for a period of 24 hours; hence further studies are recommended to assess the fluoride concentration when water is boiled and stored for different time period.

CONCLUSION

In the present study only minor changes in fluoride concentration of water boiled in five different vessels were observed. Except for the water samples that were boiled in Stainless Steel and Teflon vessel all the other water samples showed a decrease in fluoride concentration. Thus the observations of this study can be utilized for further research, to throw light on the effect of cooking vessels on the fluoride concentration in water and food prepared in vessels of different material composition.

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