Fluoride in Fish Flesh, Fish Bone and Regular Diet in South-coastal Area of Karnataka State of India

Abstract

Background: The objective of the study was to estimate the fluoride content in regular food items available, including fish, in a coastal area of the South Karnataka state of India. Materials and Methods: Fish and food samples were collected from a local market, i.e., Deralakatte, Mangalore of Karnataka State, India. Commonly consumed different species of fish (eight types are included in the study) and popular food items (twelve types) were collected through a random sampling strategy and then processed for the study. The flesh and bones of fish were separated from individual fish. Samples of flesh, bones, and food (nonfish, vegetarian food consumed by a proportion of Karnataka population) were homogenized separately, dried, and the pH of the processed samples was adjusted to neutrality (pH 7.0). Fluoride anion was determined using a fluoride ion selective electrode (ISE, Nico2000 Ltd., UK). Although the ingredients of the different fish and food items explored differed, the same processing technique and analytical laboratory bench-work procedure were performed for each sample, i.e., as per published research elsewhere. This ensured the accurate estimation of fluoride for each food item. Results: Concentrations of fluoride in foods (Nonfish, vegetarian food) was estimated ranging from 0.85 to 7.09 ppm and that in fish samples ranged from 1.45 to 2.30 ppm. The highest concentration was estimated 3.16 ppm in Rohu fish flesh, and 7 ppm in rava dosa (a vegetarian food). Conclusion: In conclusion, the Rohu (Labeo rohita) fish species were found to contain higher concentrations of bone fluoride. Fluoride determined in fish flesh was also high in concentration 2.28 ppm. Among the regular food items, rava dosa (a thin and crispy crepe made from rava and rice flour) preparation has a higher level of fluoride. These values would provide valid information regarding the future development of recommended dietary allowance strategy for a population.

Keywords: Fish, fluoride, fluoride ion selective electrode, foods, recommended daily allowance

Introduction

Globally, fluoride is widely distributed in the atmosphere, sea water, surface water, and also in underground water (varies at different level of soil depth). Indeed, it originates from rocks, soils, and gaseous wastes of Industries.\(^1\) Fluoride has beneficial effects at an optimal dose, i.e., 0.8–1.5 ppm, although it also exerts harmful effects when consumed at higher doses, i.e., >2 ppm.\(^2\) Fluoride promotes strengthening of the bone and enamel of teeth by forming less soluble hydroxyapatite crystals.\(^3\) These compounds remain in the bones and their absorption into the circulation is very limited.\(^4\) Nearly 70% of fluoride sources to the human population is available in drinking water, the remainder from various food items, drinks, tea, and supplemented dentifrices, the latter including mouthwashes and medicaments.\(^6\) The amount of fluoride available in vegetables, fruits, and meat is, however, less.\(^5\) Notwithstanding, fish sources of this anion, especially Sardine and Salmon, contains higher amounts of fluoride, as previously reported.\(^2\) The Rohu fish is one of the popular fishes consumed by millions in India, including a large proportion of the nonvegetarian population living in Karnataka; such a fish diet is readily available in costal Karnataka, and to date its fluoride level has not been determined. Therefore, there is a major interest regarding whether fluoride available in fish diets, particularly Rohu, has the capacity to exert influence over systemic and dental health.

Populations residing in coastal areas consume high quantities of fish in their diets, and therefore, there is a strong

possibility that those subjects gain a higher intake of fluoride from fish sources. Therefore, the recommended dietary allowance (RDA) for fluoride, including fish and other diets, is required to be for the determination dependence of the RDA value on age groups and gender is also of much importance. For example, in the USA, the RDA for fluoride is 3.8–10 mg for males, 3.1–10 mg for females, and 2.0–10 mg for children.[21] Therefore, an established RDA determination for fluoride is an urgent requirement for India, not only to ensure that the required amount of fluoride is attained, but also to avoid the development of fluorosis from its excessive intake.

Although there are currently reports available on the fluoride content of fish,[7] it should be noted that not only bone therein but also the flesh meat content, which are, in general, higher fluoride. Therefore, the major objective of this study was to estimate the amount of fluoride in fish flesh, fishbone, and different classes of other food sources consumed regularly by a population living in the coastal, Southern area of Karnataka, India. Such a study would, without doubt facilitate the development of a relevant fluoride RDA for Karnataka state of India.

Materials and Methods

Fish and food items were collected from the Deralakatte Market, Mangalore of Karnataka state (a suburban location adjoining the coast of the Arabian sea) of India. The study was carried out at the Fluoride and Health Research Division of the Department of Oral Biology and Genomic Studies of NITTE University (Deemed to be University) AB Shetty Dental College, Mangalore, India.

Food

Twelve different food items were included for estimation: (i) Upma (Upma made from coarser rava known as Sajjige is a dish of Karnataka cuisine. It is sometimes served along with snacks such as sautéed and spiced, (ii) Kanje red, includes rice, which is a staple food, the use of lentils and spices, dried red chilies, and fresh) (iii) Boiled rice, Rice ball, (iv) Medu Vada (Medu vada, made with urad dal (black gram) flour. This vada is shaped like a doughnut with a hole in the middle (i.e., an approximate torus). It is the most common vada type throughout South India and the most recognizable throughout India. (v) Dosa (a kind of thin cake prepared in Southern part of India made from a fermented batter. It is somewhat similar to a crepe of France in appearance), (vi) Paratha (A paratha is a flatbread that originated in the Indian subcontinent. It is still prevalent throughout regional countries), (vii) Chapathi (Indian Flat Bread, during baking it becomes fluffy) (viii) Golibaje (This is a fried dumpling made with fresh yogurt and some spices), (ix) Idli (rice cake made by steaming a batter consisting of fermented black lentils [dehusked] and rice), (x) Sambar (a hot and spicy lentil soup with mixed vegetables), (xi) White rice, (xii) (xiii) Boiled Egg, (xiv) Pulav (a rice make cuisine mixed with spices), (xv) Patrode [Prepared as thick batter with stem leaves having dosa batter consistency by grinding the soaked rice, red chili, coriander seeds, cumin seeds, grated coconut, jaggery, tamarind, and salt] (xvi) Chicken, and (xvii) Juice.

Fish

Eight different fish species i.e. (i) Rohu (Labeo rohita), (ii) Sardine (Sardina pilchardus), (iii) Bangda (Rastrelliger kanagurta), (iv) Kudchi (sub-spp: Cyprinus carpio), (v) Nang (Solefish), (vi) Shrimps (whiteleg shrimp), (vii) Kodai (Croaker Fish), and (viii) Surmin (Scomberomorus guttatus) were selected to estimating fluoride ion.

Preparation of samples from fish flesh and food

Two grams of each sample was placed in a 70 ml Nickel crucible, and a 5.0 ml volume of 8 M NaOH solution was then added to it. To dry the crucible, it was placed on a hot plate for evaporation. Subsequently, the crucible was closed with a lid and placed in a muffle furnace for 3 h at 525°C. The crucible was then cooled to ambient temperature, 10–15 ml distilled water was added to it and heated on a hot plate for dissolution of the fusion cake, a process giving rise to a solution for further processing. After 2 h, the sample solution was neutralized by adding concentrated HCl to reduce the pH value from pH 12–13 to pH 8–8.5, followed by treatment with dilute HCl to adjust the pH value to 7.2–7.5. Later, the entire neutralized sample solution was transferred to a 50 ml volumetric flask and made up to the mark by using deionized water, and then stored in an air-tight container until fluoride estimation was carried-out as according to a previously published procedure.[8] We estimated fluoride from whole preparations of nonvegetarian food items, and different fish species (flesh and bone were prepared separately were estimated). The level of fluoride in each item or ingredients of a food item may vary, but our aim is to determine fluoride level in whole food that is consumed by a population. Of course, some of the composition of nonvegetarian food may vary with its fluoride content, but our purpose was to estimate the level of fluoride in ranges from different food items (of whole preparations) consumed by the population readily. This would help develop RDA.

Preparation of fish bone sample

Individual fish samples from eight different species were measured for their length and weight [Table 1]. The bones of the fish were removed and were dried for 24 h at 105°C in a muffie furnace. Fat from the bone was removed by washing them in 98% Acetone. The fish bones were homogenized and digested in 60% (w/v) perchloric acid. It was then adjusted to a pH range of 5.0–5.5 by adding 5 M NaOH. The sample solution was transferred into a 50 ml volumetric flask and then made up to a final volume of 50.0 ml by adding deionized water according to a published procedure.[9]
Fluoride determinations

The concentration of fluoride in the samples was determined using fluoride ion selective electrode (ISE, Nico2000 Ltd., UK). Before estimations were performed, the electrode was calibrated using standard solutions of NaF (1000 ppm, 100 ppm and 10 ppm). TISAB II was added to both standard solutions of NaF and samples in the ratio of 1:1. The purpose of adding TISAB II is to adjust the ionic strength of the samples.

Results and Discussion

Fluoride in fish

The fluoride contents of fish flesh determined ranged between 1.45 and 2.30 ppm. Indeed, Rohu fish has a mean concentration of 2.28 ppm, whereas the Kodai species has lower one, i.e., 1.46 ppm. Moreover, that of the outer shell of shrimp was 1.35 ppm. Fluoride contents found in fishbone ranged between 1.35 and 2.55 ppm. Kurichi fish had the highest concentration of fluoride in bone i.e., 2.52 ppm, whereas shrimps had the least amount of fluoride in their outer shells (fibrous skin), i.e., 1.35 ppm. The mean fluoride concentration determined in Rohu fish bone was 3.16 ppm, i.e., ca. 40% higher than that of the corresponding meat flesh; these results are consistent with those of another study.[9] Results provided in Figure 1 also agree with recent reports [Figure 1].[7]

Therefore, Rohu fish has the highest fluoride content than those of all other foods tested, both in its flesh and bone. This observation may be attributable to higher levels of aquatic, fluoride-rich pollutants available in their aquatic environments, as reported in a previous study[8] (fluoride predominantly accumulates in bone and flesh). However, the Kodai fish has the least mean content of fluoride in its flesh, and this may be ascribable to lower intake levels from pollutants by this species, as previously reported.[10]

The high fluoride content of the Kurichi fish may arise from an exposure to fluoride-enriched aquatic food/sea-weeds, as –reported by Kale and Muley.[10] Shrimps have the lowest fluoride content in their outer shell since it acts as an effective biosorbent, which is also known to absorb and hence remove metal ions from aqueous solutions.[11]

Fluoride in regular (nonfish) foods

The fluoride content of the twelve different food items investigated ranged from 0.85 to 7.09 ppm. The Upma food item (a rice dish) has the highest concentration of fluoride i.e., 7.09 ppm and Parota (wheat-prepared food item) had the lowest measured value i.e., 0.87 ppm. Similar values have been previously reported.[3] Upma is prepared from rava or Semolina, and rava is predominantly grown in areas with a rich groundwater supply, although this also depends on the geographical locations where it will grow. Further studies have revealed that rava has the highest fluoride content in the localities in which the ground water has highest concentrations of fluoride.[12] Moreover, another investigation has demonstrated that the level of fluoride is greater in food products derived from areas in which the level of soil and water fluoride is high, as expected [Figure 2].[12]

Concluding Remarks

The Rohu fish contains high fluoride levels in both bones and flesh, whereas shrimps have the lowest. The popular rava dosa and upma available in South India also have the high concentration of fluoride out of all the nonfish foods evaluated here. Therefore, it is of much importance to investigate relationships between fluoride levels in foods and fish available for human consumption and those in

Table 1: Weights, size of the different fish samples

<table>
<thead>
<tr>
<th>Fish name</th>
<th>Weight (g)</th>
<th>Size (cm)</th>
<th>Weight of dried fish bone (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shrimps</td>
<td>24.9</td>
<td>12</td>
<td>0.667</td>
</tr>
<tr>
<td>Rohu</td>
<td>150</td>
<td>34</td>
<td>3.245</td>
</tr>
<tr>
<td>Kurichi</td>
<td>115</td>
<td>8</td>
<td>0.437</td>
</tr>
<tr>
<td>Nangu</td>
<td>115</td>
<td>20</td>
<td>1.703</td>
</tr>
<tr>
<td>Mackerel</td>
<td>100</td>
<td>24</td>
<td>1.482</td>
</tr>
<tr>
<td>Surmai</td>
<td>100</td>
<td>50</td>
<td>1.644</td>
</tr>
<tr>
<td>Sardine</td>
<td>70</td>
<td>20</td>
<td>1.419</td>
</tr>
<tr>
<td>Kodai</td>
<td>48</td>
<td>8</td>
<td>0.430</td>
</tr>
</tbody>
</table>

![Figure 1: Fluoride levels in different types of fish consumed in the Southern part of India](image1)

![Figure 2: Fluoride levels in different food items commonly consumed in the coastal part of Karnataka state](image2)
corresponding groundwater locations. However, there is no information available on the biological mechanisms of the Rohu fish’s ability to update and retain fluoride within its bone and flesh. Similar considerations apply to upma and rava dosa and this also requires further investigation. Since the consumption of seafood is more common in the coastal part of the country, it appears that the human population residing therein may experience a greater intake of fluoride from fish and other food items than those based more inland. However, this study serves as a key approach toward the development of a satisfactory RDA. Therefore, the broader purpose of the present study is to establish this RDA for fluoride by determining its intake from food items and drinks including external sources such as fluoride-supplemented dentifrices, mouthwashes, formula food, drinks, and external application fluoride preparations, etc.

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Conflicts of interest

There are no conflicts of interest.

References