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REGULAR ARTICLE

FLUORIDE ACCUMULATION BY VEGETABLES AND CROPS GROWN IN NAWA TEHSIL OF NAGAUR DISTRICT (RAJASTHAN, INDIA)

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SUMMARY

Fluoride is recognized as an important trace element playing a vital role in the dental and skeletal formation in human beings. It is generally believed that organisms including human being receive fluoride largely from drinking water sources and that the total daily intake of fluoride by individuals from water and other sources varies from country to country depending on the amount of fluoride present in water and other sources including foodstuffs. Earlier it was believed that food was not a rich source of fluoride for humans but it is now well documented that certain types of food can have high fluoride content. Therefore in the present investigation to study the transfer of fluoride from one tropic level to another and accumulation of fluoride in the food chain, food items were collected from nawa tehsil in nagaur district (Rajasthan) and analyzed. Leafy vegetables like spinach, radish leaves, Sarso leaves were analyzed among which spinach (25.70 µg/g) showed maximum fluoride concentration. Cereals like barley, wheat, chana, bajra, moth, chawla, methi were also analyzed for fluoride out of which methi and chawla was found to have maximum fluoride concentration (18.98 µg/g) which was collected from Shivdanpura village where fluoride concentration in water samples was found in the range between 7.36 ppm to 13.83 ppm.

Key words: Fluoride, Foodstuffs, Vegetables, Cereals, Nawa tehsil

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1. Introduction

Fluoride ion is wide spread in nature. It is estimated to be thirteenth in abundance among the elements of the earth. Pharmacologically significant is its strong affinity for calcium and other metals with which it forms highly complex compounds. Some of its action has been ascribed to its calciprive effect. Fluoride is more soluble in acid soils due to which its uptake by plants is enhanced [1]. Most food whether derived from plant or animal life, contain fluoride ion at least in minute amounts. Some foods concentrate additional fluoride ion from boiling, processing or contamination. Fluoride ions levels vary widely even between samples of the same kind of food. Some foodstuffs such as vegetables and fruits normally contain fluoride though at low concentration (0.1 mg/kg -0.4 mg/kg) and thus contribute to fluoride intake by man. Higher levels (up to 2 mg/Kg of fluoride) have been found in barley and rice [2].

In a study on fluoride balance in patients suffering from endemic fluorosis, fluoride intake in certain countries through diet was in the range of 0.2 mg/L to 2.7 mg/L [3]. Relatively low levels of fluoride in the diet are recognized as being beneficial to tooth development in humans and the addition of fluoride to drinking water is a common practice in order to improve dental health. However, elevated levels can lead to fluorosis shown by mottling of teeth and in extreme cases, bone deformities [4]. Diets high in fat have been reported to increase deposition of fluoride in bone and thus enhance toxicity [5].

Leafy vegetables are particularly susceptible to air borne fluoride ion and this accounts for wide variations in the contents of vegetables grown in different areas. Cereals usually contain < 1ppm fluoride, where fluoride tends to accumulate in the outer layer of the grain and in the embryo [6]. The fluoride contents of both leaf and root vegetables do not differ appreciably from those of cereals with the exception of spinach which is unusually enriched in fluoride. Potato peelings can contain as much as 75% of the total fluoride in the whole tuber. Tea is one of the most fluoride enriched drinks with about two thirds of the fluoride in leaves being soluble in the beverage [7]. Phosphatic fertilizers especially the super phosphates are most important source of fluoride in agricultural lands [8]. Intake of fluoride ion into roots is largely dependent on the concentration of fluoride ion in the soil and on the type of soil. In spraying experiments leaves contain more fluoride ion than stems and stems more than fruits [9]. Researchers have reported that vegetables, exposed to air borne fluoride, absorb it in their laminae [10].

High fluoride levels inhibit germination, cause ultrastructural malformations, reduce photosynthetic capacities, alter membrane permeability, reduce productivity and biomass and inflict other physiological and biochemical disorders in plants. Fluoride in water contributes significantly to the total exposure of an individual to this element but it is not the only source of exposure. A person's diet, general state of health as well as the body's ability to dispose of fluoride all affects how the exposure to fluoride manifests itself [11]. Role of diet is also responsible in causing fluorosis. Therefore Studies on fluoride uptake and accumulation were conducted using leafy vegetables, other vegetables, crops and other food items grown in some villages of the study area.

2. Materials and Methods

Nagaur district is one of the largest districts of Rajasthan in western India having its geographical area 17,718 sqkm. Nawa is one of the tehsil of Nagaur district. On the North it is bounded by Sikar district, on the east by Jaipur district, On the south by Ajmer and on the west by Makrana and Parvatsar tehsil. It is located between latitude $26^0 1'5''$ N and longitude $75^0 0'9''$ E.

Vegetables and cereals were collected from 14 villages of the study area (Nawa tehsil) where fluoride concentration in the ground water was found beyond permissible limit (> 1.5 ppm) prescribed 1.5 ppm [12]. In the study area due to low rainfall vegetables and cereals of these villages were irrigated with the fluoridated ground water. Vegetables and crops accumulate high levels of fluoride under these conditions. The fluoride concentration in the ground water samples were analyzed for fluoride by ion-selective electrode method. In the study area (Nawa tehsil) barley, wheat, bajra, moth and some vegetables were grown locally and these can easily absorb, translocate and accumulate fluoride. Food items were dried for 48 hours at 80^0C. Grinded to pass through No. 40 sieve and stored in clean dry, tightly closed plastic bottles. Bottles were rotated to mix sample thoroughly before removing aliquots. Further these samples were powdered and analyzed in the laboratory for fluoride content using potentiometric method [13]. Fluoride is extracted from dry pulverized foliage with HNO_3 followed by aqueous KOH. Potentiometric method using Ion selective electrode was observed to give more authentic results for estimation of fluoride in food samples.

3. Results

Table 1 shows the concentration of fluoride in raw food items collected from different villages of study area with varying fluoride concentration in ground water. Fluoride concentration in ground water samples (Hand-pumps, Tube-wells and Wells) of 14 villages was found to vary from 0.92 ppm to 14.62 ppm (Table 1). The present study revealed that fluoride concentration in cereal crops varied between 1.88 µg/g (Bajra from Chitawa village) to 15.88 µg/g (Chana from Chosla). Leafy vegetables grown in fluoride endemic area contain high fluoride content. In the present study maximum concentration (25.7 µg/g) was reported in spinach (*Spinacea oleoracea)* and 24.86 µg/g in Sarso leaves (*Brassica campestris*). In the study

area fluoride concentration in onion (*Allium cepa*), Radish (*Raphanus sativus*) and Methi (*Trigonella foenum-graecum*) was recorded 23.92 µg/g, 22.2 µg/g and 18.24 µg/g respectively. Other vegetables also had high fluoride content like Bathua leaves (*Chenopodium alba*) 13.94 µg/g, Kachri (*Citrullus melo var. momordica*) 13.94 µg/g, Guarfali (*Cyamopsis tetragonaloba*) 13.24 µg/g and Pea (*Pisum sativum*) 8.34 µg/g. It was reported that tomato accumulated much less fluoride, although leafy and root vegetables are reported to accumulate comparatively more fluoride [14]. Similarly it was reported that fluoride concentration in spinach (*Spinacea oleoracea*) was 38.7 µg/g, in green onion (*Allium cepa*) 22.7 µg/g, in chouli (*Amaranthus spinach*) 24.06 µg/g and in sarson (*Brassica campestris*) 15.7 µg/g in Phagi tehsil (Jaipur) [15].

Table 1 Fluoride concentration in raw food items in study area (Nawa tehsil)

S. No.	Name of the village	Concentration of fluoride (ppm)	Raw food items	Fluoride content (µg/g)
1.	Sirsi	9.46-12.28	Bajra Moth	2.76±0.22 12.6±0.35
2.	Lohrana	11.26	Bajra Chawla Moth	3.84±0.20 14.44±0.19 13.06±0.21
3.	Chosla	10.32	Barley Bajra Chana	3.84±0.15 3.70±0.10 15.88±0.12
4.	Piperali	9.46	Bajra	3.84±0.17
5.	Trisinghiya	7.36	Bajra Chawla Moth	2.76±0.25 15.88±0.12 10.46±0.19
6.	Loonwa	2.56-4.32	Bajra	3.70±0.16
7.	Lalas	4.98	Spinach Radish Radish leaves Sarso leaves Methi Mustard Bajra Barley Wheat Chana	23.12±0.19 21.42±0.11 17.36±0.13 24.86±0.20 18.24±0.15 14.44±0.18 2.88±0.20 4.84±0.12 6.96±0.21 11.74±0.23
8.	Gigore	1.57	Sarso Radish leaves Onion Sarso leaves Barley Spinach Bathua Radish Wheat Chana	10.10±0.23 10.46±0.15 8.08±0.17 24.0±0.26 1.98±0.21 19.80±0.19 13.94±0.16 15.32±0. 25 2.76±0.21 7.80±0.11
9.	Chitawa	2.49	Spinach Bajra Wheat Chana Kachri	16.76±0.18 1.88±0.14 2.88±0.11 11.34±0.10 13.94±0.13
10.	Govindi (Rulaniyo ki Dhani)	14.62	Barley Bajra	5.66±0.26 4.66±0.22
11.	Rawa	6.51	Bajra Moong Gwarfali	3.22±0.17 10.70±0.23 13.24±0.11

12.	Anandpura	0.92-2.05	Radish Radish leaves Onion Spinach Bajra Wheat Chawla	14.58±0.10 11.94±0.16 23.92±0.20 15.98±0.18 6.18±0.24 3.22±0.13 15.98±0.22
13.	Shivdanpura	7.36-13.83	Radish Radish leaves Onion Spinach Methi Bajra Chawla	17.44±0.19 10.70±0.15 17.44±0.19 25.70±0.12 18.98±0.10 7.24±0.21 18.98±0.23
14.	Sujanpura	6.68-9.64	Radish leaves Radish Pea Bathua	20.56±0.16 22.20±0.19 8.34±0.11 13.24±0.20

In the Sirsi village in Nawa tehsil (Study area) the fluoride content in bajra and moth was recorded 2.76 µg/g and 12.6 µg/g respectively. These samples were irrigated with ground water having fluoride concentration in the range between 9.46 ppm to 12.28 ppm. Cereals like Bajra, Chawla and Moth collected from Lohrana village (Nawa tehsil) were having 3.84 µg/g, 14.44 µg/g and 13.06 µg/g fluoride content respectively. Through an extensive study conducted in 1991 in the Anantapur district of Andhra Pradesh, it was pointed out that the average fluoride content in 32 locally grown agricultural crops was in the range of 0.2-11.0 mg/kg [16].

The excessive intake of fluoride due to lack of awareness resulted in dental and skeletal fluorosis in the study area. Due to financial crisis, poverty and ignorance people take less nutritious diet. Nutrition and particularly dietary deficiencies in calcium, protein and vitamin C were recognized as important exacerbating factors of fluorosis and are responsible for the endemicity of problem. The disease fluorosis in non curable but preventable. Adequate intake of food rich in calcium, Vitamin C, D, E, proteins and anti-oxidants in diet can minimize the effect of fluoride. Every village, locality should have a rain water harvesting scheme. Public awareness and health education are most important measures which should be widely adopted. This can be done by using audio-visual aids, seminars, conferences, symposium and training.

4. Discussion

Previous studies have shown that the growth and productivity of many crops are adversely affected by fluoride [17-19]. Similar to present study earlier studies confirm that fluoride has the tendency to be accumulated in the vegetable leaves [20]. Similarly it has been reported that leafy vegetables viz. Raddish leaves (*Raphanus sativus*), Spinach leaves (*Spinacea oleoracea*) and mustard leaves (*Brassica compestris*) were found to accumulate 14.96 µg/g, 29.15 µg/g and 14.59 µg/g fluoride respectively, which were irrigated with water having 3.54 mg/L to 11.82 mg/L fluoride [21].

Fluoride is entering human food and beverage chain in increasing amount through the consumption of tea, wheat, spinach, cabbage, carrots and other Indian foods [22-24]. The fluoride in these items presumably results from the use of soil or fertilizer-borne fluoridated water for food and beverage processing. The observations from studies done in China suggested that contribution from food can significantly contribute to the total fluoride uptake [25-26]. Thus, fluoride content in food should not be disregarded in assessing the total fluoride uptake. Fluoride ion in plants is derived from contaminated air and soil. Fluoride ion in the air enters the plant through the leaves, and in soil through the roots. External structure of fruits and vegetables contain more fluoride ion than internal parts. Leaves in the center of a head of sprayed cabbage had 30 ppm, whereas the outside leaves contained 34 ppm [27]. Dry

skin of bananas contained 51 ppm, whereas the fruit contained only 3.8 ppm [28]. The average fluoride ion content of vegetables ranges between 0.10 ppm and 0.30 ppm on a fresh weight basis [29]. Pineapples contain about 0.9 ppm fluoride and walnuts contain about 7.8 ppm fluoride [30].

Thus after evaluating the data of the present study it was observed that fluoride not only enters through water but also with many edible items. Fluoride of food items depends upon the fluoride contents of soil and water used for irrigation. Fluoride in water contributes significantly to the total exposure of an individual to this element but is not the only source of exposure. Fluoride in food plays a vital role in causing fluorosis whereas fluoride in drinking water plays major role. The fluoride content of the food items vary from place to place. Fluorides levels vary widely even between samples of the same kind of food. Thus it is concluded that role of diet in fluorosis has a double sword action so fluoride content in food should not be disregarded in assessing the total fluoride uptake.

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