LEACHING OF ALUMINUM AND ITS INCORPORATION TO RICE DURING COOKING UNDER DIFFERENT FLUORIDE CONCENTRATIONS IN WATER

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ABSTRACT

Majority of the people in Sri Lanka use aluminum cooking utensils for cooking rice and other types of food. Aluminum is toxic to human if injected in excessive concentrations. Since fluoride in water has an affinity to make complex ions with aluminum. Fluoride in cooking water can enhance attraction of aluminum in to the cooking medium and hence to the cooked food. Under the present study natural aluminum level and leaching of aluminum and its incorporation in to rice during cooking under different fluoride stresses were studied.

Natural aluminum level of the raw rice ***(Oryza sativa)*** was significantly large. It was observed a concentration of 0.2038 mg/g aluminum in rice. Rice cooked at the present of aluminum plate but without fluoride water shows an addition of 0.0065 mg/g aluminum to rice. An addition of 0.1367 mg/g aluminum was noted at a fluoride concentration of 6 mg/l in water which is comparative to highest fluoride levels of Sri Lankan ground water. Total aluminum was found to be high in the rice cooked under normal water as well as in the fluoride rich water. Aluminum in cooked rice increased with the increasing fluoride concentration in the water. It was found that total aluminum level in cooked rice was 0.2135 mg/g when cooked in fluoride free water and it was 0.3438 mg/g at 6 mg/l fluoride in water. The maximum allowed aluminum intake per normal person is 0.1428 mg/kg body weight per day. Based on the assumption, one person who eat 250 g rice per day, the aluminum intake according to present experiment is greater than 0.1428 mg/kg and hence risky.

Keywords**:** utensils, excessive

1. INTRODUCTION

The effects of aluminum intake for human have been reported by several workers [2, 3] and the indications are that it is neurotoxic under high fluoride stress. Leaching of heavy metals such as aluminum and lead, under high fluoride stress represents a new way for the entry of toxic heavy metals into the body and the formation of complex fluorides provides a pathway for the chemical amplification of toxins such as fluoride. While fluoride alone may not affect the organs like kidney, fluoride along with aluminum can cause a detrimental effect on the kidneys of healthy people [7].

The World Health Organization (WHO) reported in 1989 that the Provisional Tolerance Weekly Intake of aluminum (PTWI) is 7 mg/kg body weight/week [6] .Therefore; the acceptable dosage is not more than 50 mg/ day for a person weighing 50 kg. In 2006, the Joint (Food and Agriculture Organization/World Health Organization) Expert committee on Food Additives (JECFA) has re-evaluated the safety of aluminum and recommended to lower the PTWI by seven folds to 1 mg/kg body weight for aluminum [9]. This was due to the potential to affect the developing reproductive and nervous system in experimental animals at doses lower than those used in establishing the previous PTWI.

2. METHODOLOGY

2.1. Procedure for Analysis

Previously used, Aluminum rice cooking utensil was chosen. The pot was cut in to seven rectangular specimens of dimension 2.54 cm ×2.54 cm. Two kg of raw rice (*Oryza sativa*) was chosen from the local market. Ten g of rice was cooked in a glass beaker with an aluminum plate in it under different fluoride concentrated water. Samples were then digested [1] and aluminum was determined using a UV Spectrophotometer by aluminum method [5] at 530 nm.

2.2. Estimated aluminum intake for a person

The estimated aluminum intake for a person was calculated based on the assumption that an aluminum utensil of 20 cm diameter and 18 cm height is used for a family of four person (weight 50 kg) to cook one kg raw rice. The area then exposed to food during cooking is around 1440 cm^2.

2.3. Corrosion rate

The corrosion rates presented in tables are calculated by using below eq. (01).

Corrosion rate = WL/AT $(mg/cm^2.h)$ (01)

WL- is the weight loss [mg],
A - Surface area of the test specimen [cm^2]
T - Immersion time [hours].

3. RESULTS

3.1. Total aluminum in the cooked rice samples

According to the results it shows that there is a significant amount of aluminum present in the studied samples. It is important to note that aluminum presence even in the blank rice sample cooked without the aluminum plate.

The blank rice sample shows mean 0.2038 mg/g which is the lowest aluminum concentration. The highest level was detected in the sample cooked with water containing highest fluoride concentration (0.3385 mg/l).

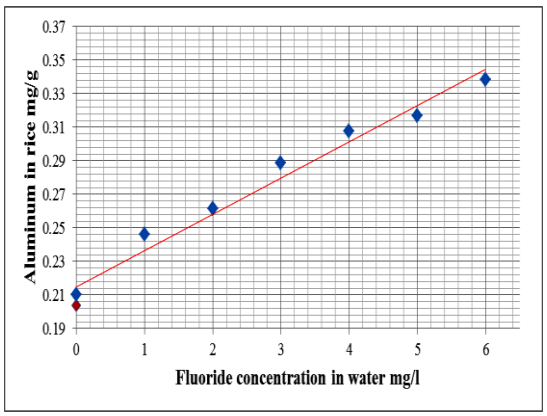

Figure 1: Total aluminum in the cooked rice sample

Table 1:Total aluminum in the cooked rice samples

Sample Number	Number of samples taken for the analysis	Mean value of aluminum present in the 1g of rice samples (mg/g)	Fluoride concentration in water (mg/l)
Blank(0)	3	0.2038	0
Sample(1)	3	0.2103	0
Sample(2)	3	0.2462	1
Sample(3)	3	0.2615	2
Sample(4)	3	0.2885	3
Sample(5)	3	0.3077	4
Sample(6)	3	0.3167	5
Sample(7)	3	0.3385	6

According to USDA food standard database [8] aluminum is not mentioned as present in rice. But the raw rice sample which was taken from the Sri Lankan local market shows significant 0.2038 mg/g of aluminum level. Therefore aluminum in local raw rice should be further investigated.

A number of reasons could probably cause presence of aluminum in rice. It could be due to rice processing method, irrigation water aluminum level, aluminum level in the soil etc. Aluminum toxicity is the major constraint to crop productivity on acid soils, which comprise over 50% of the world's arable land Under highly acidic soil conditions [4] (pH less than 5.0), Aluminum is entered in to the soil solution as Al^{3+}, which is highly phytotoxic, causing a rapid inhibition of root growth that leads to a reduced and stunted root system, thus having a direct effect on the ability of a plant to acquire both water and nutrients. Acid rain ensures that more aluminum is available for plant uptake, which often occurs and is concentrated in root tissue.

3.2. Total diet exposure of aluminum

The estimated aluminum intake for a person when fluoride water is used to cook rice is shown in figure 2

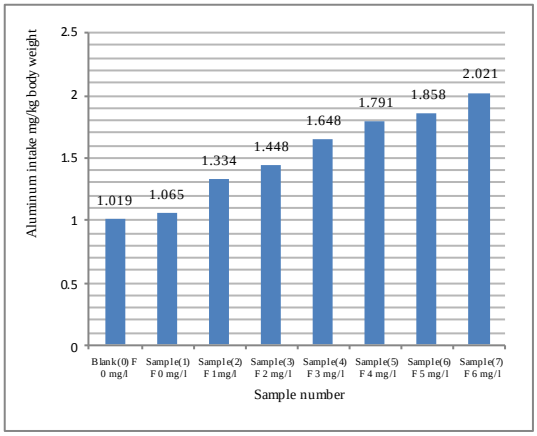

Figure 2:-Aluminum intake for 1 kg body weight (mg/kg)

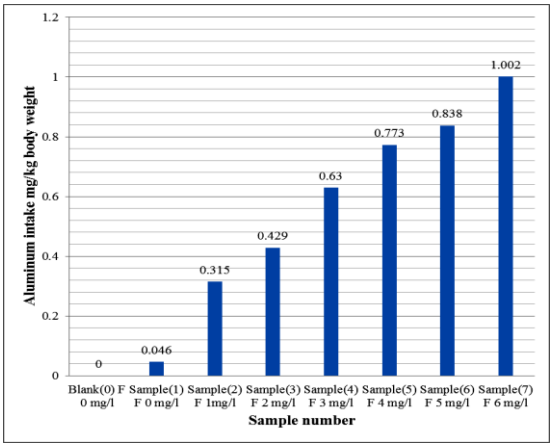

Figure 3:-Aluminum intake due to leaching of aluminum from utensil

This calculation is based on the assumption that an aluminum utensil of 20 cm diameter and 18 cm height is used for a family of four person (weight 50 kg) to cook one kg raw rice. The area then exposed to food during cooking is around 1440 cm^2.

When compared to (2006) JECFA safety aluminum level [9] of 0.1428 mg/kg of body weight, calculated values for all the samples were greater than that. Presence and absence of fluoride incorporate aluminum by leaching. In addition, rice may alone have a significant amount of aluminum. According to Department of Census and Statistics Ministry of Finance and Planning Sri Lanka 2010/09 survey daily "kakulu" rice consumption exceeds 250 g/ day. Therefore people in Sri Lanka are under risk of excessive aluminum intake, especially in areas where fluoride rich in ground water.

3.3. Diet exposure of aluminum from utensils

According to the observations there is a significant amount of aluminum present in natural raw rice sample. By subtracting the amount of aluminum occurring in raw rice exposures due to leaching of aluminum utensils can be re calculated as shown in the figure: 3.

3.4. Corrosion rate

Corrosion rate of the aluminum depends on the surface area of aluminum plate, rice itself, fluoride concentration and length of cooking time. The table 6.4 presents corrosion rate for different fluoride stresses. The maximum and lowest rate of corrosion is 0.3129 (mg/cm^2) and 0.0143 (mg/cm^2) respectively for 20 minute cooking time. The maximum rate of corrosion is observed when cooked with 6 mg/l fluoride water and the lowest rate of corrosion in cooking where fluoride free water. There is an increment of corrosion rate with respect to the fluoride concentration. Also result shows rice alone may leach aluminum.

Table2: Corrosion rate of the aluminum due to presence of the fluoride and rice

Fluoride concentration of water used to cook rice for 20 minutes (mg/l)	Weight loss of the aluminum specimen	Corrosion rate (mg/.cm^2. hr)×10^{-2}
0	0.0641	1.43
1	0.4231	9.83
2	0.5769	13.4
3	0.8462	19.6
4	1.0385	24.1
5	1.1282	26.2
6	1.3462	31.2

4. CONCLUSION

- The present study indicated that use of aluminium utensils in the presence of fluoride rich water for cooking pose a threat to the rice consumer with increased aluminium intake.

- Raw rice appear to contain significant amount of aluminium

- Aluminium leaching from aluminium utensils increase with the increasing fluoride content in cooking water.

- Combined aluminum contribution from rice, cooking utensils, and other food such as curries cooked in aluminium utensils particularly in acidic medium could be higher than the acceptable levels and hence pose a threat to consumer especially in the areas of fluoride rich ground water.

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