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Aluminium uptake by some foods from the aluminium cookware during cooking and effect of fluoride on the uptake

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ABSTRACT

Aluminimum uptake by some foods from the aluminium cookware during cooking has been studied. Various food items studied were pulses of green gram (Phaseolus aureus Roxb), red gram (Cajanas cajan) and lentil (Lens escunenta), vegetables of potato (Solanum tuberosum), cabbage (Brassica oleracea), and chutneys of tomato (Lycopersicon esculentum) and tamarind (Tamarindus indica). Affect of the presence of fluoride in the cooking water on the uptake of aluminium by the foods from the aluminium cookware has also been studied. Results revealed an aluminimum uptake of 21.6 to 32.1 mg/100gm by the pulses. The vegetables uptook comparatively lower amount (4.41 to 13.54 mg) of Al. The chutneys uptook larger quantity (18.24 to 22.51 mg) of Al. pH seems to be one of the factor in deciding the quantity of aluminium uptake from the cookware. Other factors such as complexones/chelating agents of the food might also be the factors, ruling the Al uptake. Presence of fluoride (5 ppm) in the cooking water resulted in an enhanced uptake (20.09 to 43.26%) of Al from the cookware.

Key words: Aluminium, Aluminium toxicology, Aluminium uptake, Aluminium cookware, Fluoride toxicity.

INTRODUCTION

Aluminium is the third most abundant element in the earth's crust. It comprises about 8% of the outer 16 kms of the crust. It is a highly reactive metal enhance does not occur free in nature. It occurs chiefly as oxides and complex aluminosilicates. Despite its abundance, aluminium does not have any useful biological function. It has been rather proved to be toxic to human body [1-14]. Aluminium has been implicated as potential neurotoxic factor in different pathological conditions[6,7]. The extensive use of aluminium cookware and food packaging material and use of aluminium salts in food additives and some drugs, provide potential sources of aluminium ingestion. Aluminium may enter into the body through food, water and air borne dust particles[9].

With the above views in mind, we have presently studied the aluminium uptake by some foods from the aluminium cookware during cooking. Various food items studied were pulses of green gram (*Phaseolus aureus Roxb*), red gram (*Cajanas cajan*) and lentil (*Lens escunenta)*, vegetables of potato (*Solanum tuberosum*), cabbage (*Brassica oleracea*), and chutneys of tomato (*Lycopersicon esculentum*) and tamarind (*Tamarindus indica*). Affect of the presence of fluoride in the cooking water on the uptake of aluminium by the foods from the aluminium cookware has also been studied.

MATERIALS AND METHODS

Aluminium vessel and aluminium skillet were procured from local market. The vessels were non-surface treated. For control purpose the vessel and skillet used were of stainless steel. Various food items viz., green gram (*Phaseolus aureus Roxb*), red gram (*Cajanus cajan*) lentil (*Lens escunenta*), potato(*Solanum tuberosum*), cabbage (*Brassica oleracea*), spinach (*Spinacia oleracea*), tomato (*Lycopersicon esculentum*)and tamarind (*Tamarindus indica*) were also procured from the local market. Water used for cooking was the filtered tap water.

Cooking of pulse : 25g of green gram, red gram and lentil were cooked separately with 500 ml water in an aluminium vessel, covered with aluminium lid. Requisite amount of salt and turmeric powder were added. The pulses were cooked till done.

Cooking of vegetable: 50g of potato, cabbage and spinach were cooked separately. The vegetables were cut into small pieces and were cooked in 500 ml water in an aluminium vessel, covered with aluminium lid. Requisite amount of salt and turmeric powder was added and cooked till done.

Cooking of tomato chutney : 100g of tomato were mashed and slightly fried in mustard oil in an aluminium skillet, 500 ml water was added. Requisite salt was also added and sauté for half an hour and cooked.

Cooking of tamarind chutney : 50g of tamarind was cooked in 500 ml water for one hour in an aluminium skillet. Requisite amount of salt was also added. At the end, the tamarind was mashed in the skillet & seeds were removed. The mashed products then cooked for half an hour. The pasty material was then slightly fried in mustard oil.

For comparative and blank (control) purpose the above food items were also cooked in stainless steel vessel and skillet, as the case may be. The quantity of the ingredients and cooking procedures were exactly same as that of experimental (cooking in aluminium vessel).

Estimation of the aluminium uptake by food : The food cooked in each of the above case was homogenized in an electrical mixture using appropriate volume of water. The volume and the pH of the homogenate noted. 100 ml of homogenate was taken into a 250 ml. conical flask and treated with 10 ml. of 1 M HNO_3 and evaporated off to a small volume (approximately 25 ml.). Next, it was filtered quantitatively into a 100 ml. volumetric flask and the volume of the filterate was made to the mark (100 ml) with the distilled water. Aluminium in this solution was estimated spectrophotometrically using Eriochrome Cyanine R reagent[15]. From this the total aluminium present in the homogenate was calculated out. Finally the release of aluminium from utensil to the food in mg/100 g was calculated out.

Experiments with fluoridized water : A calculated quantity of sodium fluoride was weighed out and added to appropriate volume of water so as to get fluoridized water of 5ppm fluoride ion (F^-) concentration. This water was used in place of tap water to cook all the above food items in exactly same quantity and exactly with the same procedure, in aluminium vessel/skillet. Aluminium uptake by the food items were also calculated out exactly as mentioned above.

All the above experiments were carried out in five replicates and the mean aluminium uptake by the food items in each case were found out.

RESULTS AND DISCUSSION

Aluminium uptake by the foods from the aluminium cookware during cooking is recorded in Table- 1. Aluminium uptake by the foods form the aluminium cookware, with fluoridized water as the cooking medium is recorded in Table- 2. Fluoride induced Al-uptake by the foods is recorded in Table-3.

Food is a potential source of aluminium ingestion into the body. With the use of aluminium vessels for cooking, aluminium ingestion through food is quite likely. As seen from the Table- 1, the pulses (green gram, red gram and lentil) and the acidic foods (tomato and tamarind chutney) uptake larger amount of aluminium from the utensil as compared to the vegetables (potato, cabbage or spinach) . pH seems to be one of the factors affecting the quantity of aluminium uptake; but some other factors, probably chelating agents of the foods, seem to dominate in deciding the quantity of aluminium uptake. The pulses have dragged larger quantities of aluminium viz., red gram 32.1 mg, green gram 26.08 mg and lentil 21.6 mg/100 gm food. Even though the pH of their homogenate were ranging from 5.5 to 6.5 . Among the pulses, however, the pH seems to matter, red gram with lowest pH (5.5) dragged maximum of 32.1 mg Al, whereas lentil with higher pH 6.5 dragged a low quantity of 21.36 mg aluminium; green gram with intermediate pH (6.0) uptook 26.08 mg Al, a value between that of red gram and lentil. Among vegetables, potato (pH =6.0) absorbed 13.54 mg Al where as cabbage and spinach both at pH 5.5 (lower than potato) absorbed only 4.41 and 11.76 mg Al respectively. Among chutneys, tamarind with the lowest pH (3.0) absorbed 22.51 mg Al, whereas tomato with slightly higher pH (4.5) absorbed a little lower, 18.24 mg Al. The chutneys being the most acidic foods among those we have cooked, have quite expectedly uptook larger quantities of aluminium with a trend of lower the pH higher the absorption. On the whole looking at the results pH seems to be one of the factors affecting the aluminium absorption from the vessel. Other factors might be the presence of complexing agents in the foods, their ability to be released during cooking process etc. The various chelating agents in foods might be coming from the hydrolysis of complex organic molecules such as proteins, carbohydrates, peptides etc. during cooking. Pulses with high phosphoprotein content might be releasing the polyphosphates by hydrolysis, during cooking, which in turn might be acting as suitable complexone/chelator for aluminium. This might be a factor behind a high uptake of Al by the pulses even though the pH of their homogenate was not as low as that of chutneys. The vegetables, particularly cabbage, seems to be a poor absorber of Al. In fact cabbage showed the lowest absorption of a meager 4.41 mg Al. Lack of release of suitable complexing agents for aluminium by the vegetables (particularly cabbage) seem to be the reason behind this. On the other hand, it may also be the fact that the complexones are released but they are not suitable in ring size etc. for formation and stabilization of their aluminium chelates.

Migration of aluminium from cookware to food is likely to be affected by a number of anions and cations. Infact such observations have earlier been made. Fluoride when present has been reported to enhance the migration of aluminium from cookware into the food[16]. However, the exact quantification of the data is not available. Fluoride generally enter into the cooking medium through water. Fluoride has been depicted to be a double edged sword. Lack of fluoride in drinking water leads to the formation of dental caries whereas excess of fluoride leads to a disease called Fluorosis, which manifests in the form of tooth decay, faulty bone mineralization, osteomalacia etc. The acceptable limits of fluoride in the drinking water is 0.5 to 1.5 ppm[17-21]. There are many endemic fluorosis belts in different geographical regions including India . In some fluorosis belts in India the fluoride content of water has been reported to be as high as 6.5 ppm[22]. In endemic fluorosis belts, where there is excess of fluoride in drinking water, cooking in aluminium vessels might lead to an enhanced uptake of aluminium by the foods from the cookware. With our interest in this fact, we have cooked different foods in fluoridized water (F^- = 5 ppm)

Study of Table–2 suggest that the presence of F^- ion in general has enhanced the quantity of aluminium uptake by the different food items. For pulses, there has been increase of 5.24 to 9.24 mg/100g of Al compared to those cooked without fluoride. In case of vegetables, the fluoride induced enhanced migration of Al was found to be 1.71 to 3.93 mg/100g. In case of highly acidic foods like tomato and tamarind chutney, the enhanced uptake of Al (F^- induced) was found to be in the range of 6.73 to 7.41 mg/100g (Table-3). Thus, upon chronic exposure to aluminium through cooking utensils in fluorosis belt there might occur severe aluminium toxicity.

The provisional tolerable weekly intake for Al as a contamination suggested by the World Health Organization (WHO) is 7 mg/kg body weight for adults[16]. For children, a daily intake of 2 mg is commonly used for the assessment of toxicity risk[16].Thus as seen from our present observation, the cooking in aluminium utensils, particularly the acidic foods, would lead to chronic aluminium toxicity.

Table – 1Aluminium uptake by the foods from aluminium cookware during cooking

Food	pH of homogenate	Mean aluminium uptake by the food (mg/100g)			Sample size
		Experimental set (Al Vessel)	Control Set (Stainless steel vessel)	Al released from vessel (Experimental- control)	
Green gram	6.0	26.95	0.87	26.08	5
Red gram	5.5	33.03	0.93	32.10	5
Lentil	6.5	22.48	1.12	21.36	5
Potato	5.5	14.61	1.07	13.54	5
Cabbage	5.5	5.30	0.88	4.42	5
Spinach	5.5	12.49	0.73	11.76	5
Tomato chutney	4.5	19.38	1.14	18.24	5
Tamarind chutney	3.0	23.76	1.25	22.51	5

Table – 2 Aluminium uptake by the foods from aluminium cookware during cooking in fluoride (5 ppm) treated water

Food	pH of homogenate	Mean aluminium uptake by the food (mg/100g)			Sample size
		Experimental set (Al Vessel)	Control Set (Stainless steel vessel)	Al released from vessel (Experimental- control)	
Green gram	6.5	32.26	0.94	31.32	5
Red gram	6.0	42.45	1.13	41.32	5
Lentil	6.0	31.58	0.98	30.60	5
Potato	5.5	18.54	1.07	17.47	5
Cabbage	4.5	7.00	0.87	6.13	5
Spinach	5.5	15.05	0.73	14.32	5
Tomato chutney	5.0	26.80	1.15	25.65	5
Tamarind chutney	3.0	30.20	0.96	29.24	5

Table – 3 Fluoride induced aluminium uptake by the foods from the aluminium cookware

Food	Mean aluminium uptake by the food (mg/100g) from aluminium utensil		Fluoride induced aluminium uptake by the food (mg/100g) (b-a)	Sample size
	In the absence of fluoride (a)	In the presence of fluoride (5 ppm) (b)		
Green gram	26.08	31.32	5.24	5
Red gram	32.10	41.32	9.22	5
Lentil	21.36	30.60	9.24	5
Potato	13.54	17.47	3.93	5
Cabbage	4.42	6.13	1.71	5
Spinach	11.76	14.32	2.56	5
Tomato chutney	18.24	25.65	7.41	5
Tamarind chutney	22.51	29.24	6.73	5

CONCLUSION

Our present studies on aluminium uptake by foods from the aluminium cookware indicate that the use of non surface-treated aluminium vessel for cooking purpose posses a great threat of aluminium toxicity. Presence of fluoride in water would lead to 20.09 to 43.26 % increase in aluminium uptake from the utensils. Thus aluminium toxicity would be more severe in endemic fluorosis belts.

Aluminium and Calcium are competitive elements. Under low calcium content of the food, gastrointestinal absorption of aluminium is more. As such in places where there is low calcium content of drinking water and where there in poor calcium intake, the aluminium toxicity would be more prevalent, if aluminium cookware are used for cooking purpose. Thus there is a need for educating the people at large, particularly the rural folk, about the adverse effect of the use of aluminium cookware.

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