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Aluminium utensils: Is it a concern?

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ABSTRACT

Aluminium utensils are ubiquitous in Indian households and other developing countries. Concerns have recently been raised on the pathological effects of aluminium on the human body, due to its leaching from utensils with long-term use, which has been associated with certain clinical conditions such as anaemia, dementia and osteo-malacia. While some studies suggest that cooking in utensils or aluminium foils is safe, others suggest that it may lead to toxic levels of aluminium in the body. However, studies have shown that leaching of aluminium from cooking utensils depends on many factors such as pH, temperature and cooking medium. In healthy controls, 0.01%–1% of orally ingested aluminium is absorbed from the gastrointestinal tract and is eliminated by the kidney. Although the metal has a tendency to accumulate in tissues and may result in their dysfunction, the literature suggests that the apprehension is more apt in patients with chronic renal insufficiency. This article offers solutions to mitigate the risk of aluminium toxicity

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INTRODUCTION

Aluminium (Al) in its various forms is a part of most households in India. Aluminium wrought utensils are commonly used in developing countries for the purpose of mass cooking in the army and hostel messes, and as aluminium foil in cooking and food packaging in both developing and developed countries.[1,2] Due to this extensive application for a long duration, concerns have been raised for its safety in human beings as some recent evidence suggests that aluminium leaching from cookware and foils may cause illnesses such as anaemia, dementia and osteomalacia.[3] We review points in favour and against this issue to address the rising public interest in recent years on the effects of aluminium on human health.

MANUFACTURE OF UTENSILS

Aluminium metal has certain physical and chemical properties that make it usable for fabricating utensils. Its density of 2.7 g/cm^3 is nearly one-third of steel (7.83 g/cm^3) making it lightweight. Alloys in which manganese, copper and zinc are used with aluminium as the predominant metal, have a high strength. These alloys also resist progressive oxidization. When exposed to air, aluminium combines with oxygen to form an inert and colourless aluminium oxide film on the exposed surface which blocks further oxidation. Moreover, aluminium when adequately alloyed and anodized can resist corrosion by water, salt and other environmental agents, and by a wide range of other chemical and physical agents.[4] Thus, lightweight, strength, durability, good welding and chemical resistance are few of the desired properties of aluminium that allow design and manufacture of utensils convenient for day-to-day purposes.

ABSORPTION AND EXCRETION IN HUMAN BODY

In healthy controls, 0.01%–1% of orally ingested aluminium is absorbed from the gastrointestinal tract and is primarily eliminated by the kidney.[5] The Joint Food and Agriculture Organization (FAO)/WHO Expert Committee on Food Additives (WHO JECFA) has established a provisional tolerable weekly intake (PTWI) of aluminium as 2 mg/kg body weight in 2011.[6] It is known that aluminium has a tendency to accumulate in tissues and organs, which may result in their dysfunction. However, the concern is more relevant in individuals with chronic kidney disease (CKD).[5]

ACCUMULATION IN PATIENTS WITH CHRONIC RENAL INSUFFICIENCY

Since aluminium is primarily excreted by the kidney, its accumulation is an important concern in patients with impaired renal functions. It can get accumulated in organs such as bones, brain and other tissues and is associated with toxic sequelae. Accumulation of aluminium in the brain appears to be a major cause in the development of a neurological syndrome called 'dialysis encephalopathy' or 'dialysis dementia' and a specific form of osteomalacia (aluminium bone disease) due to accumulation in the bone.[7] Another concern is hyperphosphataemia which develops in individuals with impaired renal function. Aluminium-containing agents were one of the treatment options for hyperphosphataemia, but they are no longer widely used due to concerns of toxicity.[8] On initiation of chronic dialysis therapy in patients with CKD, aluminium toxicity with increased risk of morbidity and mortality in patients with uraemia can be seen. There are various sources of aluminium loading in patients with uraemia such as parenteral exposure, enhanced gastrointestinal absorption and reduced ability to excrete systemically administered aluminium leading to toxicity. This toxicity can be prevented by using aluminium-free water for dialysis, substituting aluminium with other phosphate-binding agents and avoiding concomitant use of citrate and aluminium-containing compounds.[5,9] After modifications of dialysis protocols to minimize aluminium exposure, the incidence of dialysis encephalopathy has decreased in recent years.[5,9]

An open-label randomized controlled trial was conducted to address the issue of aluminium accumulation in 42 patients with chronic renal insufficiency. A test group of 30 participants used stainless steel utensils while the control group of 12 participants used aluminium utensils for cooking food for 3 months. The study found a significant increase in transferrin saturation, and significant

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decrease in serum and daily urine aluminium excretion in the test group compared to those of the control group.[10]

TOXICOLOGICAL EFFECTS

Aluminium does not have any physiological function, but many adverse effects have been attributed to it. It is a competitive inhibitor of iron, magnesium and calcium, and has been associated with osteomalacia (aluminium bone disease), dialysis encephalopathy and anaemia.[3]

It is also implicated in the pathogenesis of Alzheimer disease (AD), breast cancer and pathological changes in the lungs, but the association is not yet confirmed.[11,12] A study was done to develop an animal model of AD using intracisternal injection of aluminium maltolate in aged rabbits. Pathological changes seen were similar to the neurological, biochemical and behavioural changes seen in patients with AD. The neurodegenerative effects include oxidative stress, apoptosis and the formation of intraneuronal neurofilamentous aggregates that are tau-positive. However, the hypothesis is still unproven.[12]

CONCERN FOR ALUMINIUM TOXICITY: FACT OR MYTH?

Food additives, drinking water and leaching from aluminium cooking utensils are some of the sources of exposure to aluminium.[1] Evidence suggests that cooking in aluminium utensils or using aluminium foils is not harmful.[13,14] On the contrary, some studies suggest it may lead to toxic levels of aluminium in humans.[15,16] Many studies have shown leaching of aluminium from cooking utensils, but this phenomenon depended on many factors such as pH, temperature, cooking medium, composition of food, duration of contact/cooking and presence of fluoride, sugar, salt and organic acid.[17,18] Studies have been done to measure the amount of aluminium leaching from cookware and to estimate aluminium content in vegetable extracts (tomato, onion, potato, green beans, carrots and zucchini), boiled meat extracts (lamb, chicken and fish), liquid fresh milk and long-life milk by using gravimetric and atomic absorption methods. Scanning electron microscope was used for the surface study of the utensils. It was found that aluminium leaching from aluminium cookware into different samples varied and depended on aluminium composition, kind of extracts (e.g. more in tomato extract due to its acidic nature), water quality, table salt, temperature and immersion time.[17,18]

Cooking and storing food in aluminium foils is a major source of aluminium exposure in developed countries. Ranau *et al.* estimated the levels of aluminium leaching in fish fillets baked and grilled in aluminium foils.[13] Their results suggest that aluminium leached from the aluminium foil into the food, but the leaching depended on several factors such as duration and temperature of heating, composition and pH of food, presence of other substances such as organic acids and salt, and dissolution of the metal due to chemical reactions. They concluded that there was no risk to the health of the consumers from eating food prepared in aluminium foils considering the PTWI of 1 mg/kg body weight (PTWI of aluminium was 1 mg/kg body weight till 2010. It was changed to 2 mg/kg body weight in 2011 by WHO JECFA).[13]

Thus, it seems reasonable to infer from different studies that the amount of aluminium leached in food, beverages such as tea and coffee, and drinking water depends on many physical and chemical factors and can reach toxic levels in normal human beings only under certain specific conditions.

REGULATIONS IN INDIA

The Bureau of Indian Standards (BIS) has outlined specifications for aluminium and aluminium alloy to be used for cooking utensils regarding material, thickness, fabrication, abrasion resistance and finishing.[19] According to the BIS, aluminium utensils used for cooking should have a high grade of smoothness which is obtained by coating of aluminium oxide and anodizing the surface.[20] The thickness of the coating should be 50–100 μm. It should be smooth, continuous and done at the end of the manufacturing process.[20] The extent of leaching of aluminium from such utensils is minimal. All manufacturers should abide by these rules to help secure the health of the consumers. The BIS has also directed consumers to follow the cleaning technique of aluminium utensils as per instructions from the manufacturer.[19]

POSSIBLE SOLUTIONS TO THE PROBLEM

Anodization of cookware increases the thickness of the oxide layer which is protective against leaching of the element into food.[21] A study showed that the amount of aluminium leached from anodized aluminium cooking utensils is equivalent to the amount leached from stainless steel utensils.[22] The authors studied leaching of aluminium during the preparation of various traditional Indian foods and found that it was negligible in hard anodized aluminium utensils, showing the advantage of using such vessels for food preparation over simple aluminium and indalium utensils.[22] Thus, if the manufacturers strictly follow the guidelines for wrought utensils laid down by the BIS, there is little risk of adverse effects on human health by cooking food in aluminium utensils and using aluminium foil.

An important point to note is the cleaning technique of aluminium utensils. Cooking utensils should be cleaned with soft materials and precautions should be taken to preserve the protective anodized layer. Manufacturers instruct that these utensils should never be rubbed with hard or metallic scrub.[23] The risk of aluminium leaching is minimal if the inner surface coating is preserved, and so is the risk to human health. However, cleaning practices prevalent in the community involve the use of a hard or metallic scrub which leads to erosion of the protective coating. Moreover, cooking at high temperature also causes extensive leaching predisposing to aluminium toxicity.[17,18,21,22]

Conclusion

Toxicity due to leaching of aluminium into food while cooking in aluminium utensils depends on many factors. Its association with conditions such as mouth ulcer, AD, depression and anxiety is not scientifically well established. The concern is more relevant in patients with impaired renal function where attention is warranted. We did not find any conclusive evidence of aluminium toxicity among the general population as long as manufacturers and users stick to their respective roles and responsibilities. Thus, the scientific evidence suggests that the smooth inner surface of utensils should be maintained and, materials and washing techniques that have the potential to destroy the protective anodized layer should be avoided.

Conflicts of interest. None declared

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