Aluminum (Al) - importance for the body and health, where it is contained

Eliseeva Tatyana, editor-in-chief of the EdaPlus.info project

E-mail: eliseeva.t@edaplus.info

Abstract. The article discusses the main properties of aluminum (Al) and its effect on the human body. A systematic review of modern specialized literature and relevant scientific data was carried out. The best natural sources of aluminum are indicated . The use of the mineral in various types of medicine and the effectiveness of its use in various diseases are considered. The potentially adverse effects of aluminum on the human body under certain medical conditions and diseases are analyzed separately.

Keywords: aluminum , Al , aluminum, useful properties, contraindications, sources

It is one of the most common metals in the environment. Today, it is ubiquitous and its levels are increasing due to human influence on nature, which does not bode well for health. The neurotoxic agent can accumulate in the brain, provoke diseases and interfere with the absorption of other metals.

Aluminum in the body - good or bad

The trace element does not have an important function or role in the body, so its content in any part of the body is not considered the norm. Approximately 50% of the substance coming from outside is concentrated in the bone tissue, and 25% in the lungs (the percentage increases with age). A small concentration may be harmless, and the degree of absorption depends on the form and many factors: nutrition, the presence in the diet of such chelators as citric and lactic acid. [one]

With the blood flow, the element is transferred to the kidneys, which remove most of it. If their functions are reduced, the process deteriorates, leading to a toxic load. [2, 3]

Aluminum content analyzes

There are several ways to determine metal intoxication:

- bone biopsy;
- analysis of blood, urine.

If you have symptoms that indicate metal poisoning, your doctor may order a blood test. However, this indicator does not show the load on the organs - to confirm the diagnosis, it is necessary to check the bone marrow.

Aluminum in food and the environment

A person receives the toxin from different sources:

- vegetables, fruits, drinking water and processed foods (sausages, cheeses, etc.);
- food packaging;
- aluminum foil;
- kitchen utensils, baking sheets;
- cosmetics - antiperspirants, sunscreens, toothpaste;
- drugs - antacids for the treatment of acid-dependent diseases of the gastrointestinal tract, etc.

The metal gets into food in many ways, not just naturally from the soil. Levels may be higher due to the use of food additives (sulfates, phosphates, etc.), cooking in aluminum cookware, storage in aluminum-containing containers and cans. Most people are exposed to aluminum through additives that are considered harmless but pose potential dangers. [four]

As a result of soil acidification, the compound enters the aquatic environment, which leads to its accumulation in fish and marine plants. The level in drinking water is also rising - aluminum sulfate is added to it for purification. Scientists believe that human exposure to the substance is mainly food - drinking water accounts for less than 5% of oral intake. [5, 6]

Aluminum in products - what kind of food should be feared?

The highest metal content was found in vegetables, fish, seafood, root crops and tubers. The concentration in various types of fish, seafood, meat depends on the origin. Animals accumulate the mineral from the same sources as humans. [7, 8, 9, 10, 11]

The content of aluminum in vegetables and fruits depends on the variety, irrigation water and soil. The highest concentrations have been found in Spain in the Canary Islands, where the soil is acidic due to its volcanic nature. [13, 14, 15]

You may also not realize that some of the element gets into the food during cooking - it comes from foil, pans, pots and even cutlery. This is especially true for sour and spicy foods. [12]

The content of aluminum in products of plant and animal origin

No.	Product	mg/l, mg/kg in 100 g ± standard deviation
one	instant coffee	0.02–0.581
2	fruit juices	0.04–4.1
3	apple fresh	0.14
four	Pork	0.2

5	Yogurt	0.7±0.5
6	Milk	0.7±1.5
7	Ham	1.9±0.4
eight	Wine	2
9	Homogenized chicken eggs	2.9±2.9
ten	Bologna sausage, salami	3.06±1.09
eleven	Green beans, cooked	3.4
12	white fish	3.5±3.2
13	Cheddar cheese	3.9
fourteen	Fish, fatty varieties	3.9±1.9
fifteen	Citrus	4.7±3.3
16	Tomatoes and onions	5.4±2.1
17	Bird, rabbit	6.3±2.8
eighteen	Seaweed	7–27
19	red meat	9.3±4.8
twenty	Peaches, pears, plums	9.6±6.8
21	by-products	11.1±6.4
22	baked potatoes	26
23	Zucchini, carrots, courgettes, cabbage, watercress, spinach	27.4±38.4
24	processed cheese	29.7
25	Banana	32–33

The aluminum content in edible seaweed is higher than in fish - they can accumulate metals from the water and in some cases act as bioindicators of pollution. [16]

Safe daily dose of aluminum

WHO has established a safe daily dose of 40 mg/kg per day. Other organizations consider the average intake to be 10–15 mg/day. However, when taking drugs, the dose can reach 1 g / day, which is dangerous for health - even a healthy body finds it difficult to get rid of excess. [17, 18]

Interaction of aluminum with trace elements:

- calcium citrate and fluorine increase the absorption of the mineral from food, drinks;

- silicon and zinc reduce absorption. [24, 25]

How to reduce the absorption of aluminum?

Aluminum pots and other kitchen utensils oxidize, forming an inert layer that prevents metal from penetrating food. After cleaning the surface, the protective layer is erased, and aluminum can seep into the food. This is easy to avoid: you need to boil water in the dishes several times until the bottom becomes dull. After that, the containers will not look so shiny, but a little trick prevents leaching.

Aluminum foil is disposable and cannot be inert before use. In this case, the migration of the mineral into food may exceed the permissible limits. Therefore, baking food in foil is dangerous. For this, it is better to use baking paper. [26, 27]

The use of aluminum in medicine

Metal chloride is part of the drugs to stop capillary, gingival bleeding. Aluminum hydroxide is taken to treat stomach ulcers, and its forms are also added to vaccinations to increase their effectiveness. The risks associated with such vaccines are controversial.

Aluminum in scientific research

- The presence of the mineral in the daily diet can impair memory. Scientists have proven this with a 60-day low-dose study in rats. They added concentrations to food and water that reflected the average human intake of aluminum. Within two months, oxidative stress increased in all subjects, antioxidant protection decreased, memory and other cognitive functions were impaired. [28]
- Aluminum accelerates brain aging. It impairs speech, memory, the ability to recognize objects and make purposeful movements. It also contributes to the growth of certain age-related neurological diseases, such as Alzheimer's disease, Parkinson's. [29]
- The content of aluminum in drinks from aluminum cans is higher than from glass containers. In addition, the lower the pH of the content, the greater its concentration. Therefore, drinks from aluminum cans, especially soft drinks, can be a risk factor. [thirty]

- Foods baked in aluminum foil contain more metal. For fish, chicken, the maximum concentrations are 40–42 mg/kg. The leaching of Al into beef was slightly higher as it contains some organic acids that promote greater absorption. [31]
- The treatment of aluminum toxicosis includes several stages, and one of them is the intake of the chelating agent deferoxamine, based on succinic and acetic acid. After intravenous administration, the drug improves the condition of the bones and brain. Antioxidants and free radical scavengers such as selenium, melatonin, boric acid, vitamin C are also used. They reduce oxidative stress, and quercetin reduces the death of brain neurons. [32]

The harm of aluminum and its dangerous properties

- **Causes neurodegenerative diseases.** The main target of the component is the nervous system. Its high concentrations have been found in the brain tissues of patients with Alzheimer's disease. Scientists have come to the conclusion that this type of dementia appeared as a result of changing living conditions and is associated with industrialization. [19]
- **Dangerous for people with kidney failure.** If the kidneys do not work well, the element is not excreted and accumulates in the tissues. Studies have shown that this is often experienced by people diagnosed with kidney failure. [twenty]

- **Damages bones.** The metal is absorbed in the intestines and quickly transported to the bones, disrupting their mineralization, growth and activity of bone cells. Its toxic effects are cumulative and even intermittent or low-dose intake of the toxin increases the overall burden on the skeletal system. [21]
- **Reduces cognitive functions.** Studies have confirmed that workers in factories that come into contact with aluminum experience reduced mental function. The more metal and the longer its impact, the worse attention and memory. [22, 23]

The effect of aluminum on the body: consequences and complications

Side effects are associated with high metal levels, poor health. Consequences are determined by the number, duration and method of exposure.

Symptoms of excess aluminum

- confusion;
- muscle weakness;
- bone pain
- convulsions;
- speech problems;
- slow development in children;
- lung problems;
- problems with the nervous system - encephalopathy, cognitive and motor disorders;
- iron malabsorption, anemia;
- brain diseases;
- immune and allergic reactions.

Expert comment

Tatyana Eliseeva, nutritionist, nutritionist

The metal belongs to substances of the 3rd hazard class. It is inevitably present in our diet, because it is most concentrated in vegetables, fruits, seafood. Its amount in food sources has increased so much in recent years that even its low absorption in the gastrointestinal tract does not save people.

That is why the metal poses a risk to the health of every person. Reducing its consumption is simple - just give up kitchen utensils with a harmful component, foil and highly processed food. Natural whole foods contain the least amount of not only aluminum, but also other dangerous compounds.

Literature

1. Ganrot, P.O. (1986). Metabolism and possible health effects of aluminum. *Environmental health perspectives* , 65, 363-441. doi:10.1289/ehp.8665363
2. Shaw, CA, & Tomljenovic, L. (2013). Aluminum in the central nervous system (CNS): toxicity in humans and animals, vaccine adjuvants, and autoimmunity. *Immunologic research* , 56(2), 304-316. DOI: 10.1007/s12026-013-8403-1
3. Nayak, P. (2002). Aluminium: impacts and disease. *Environmental research* , 89(2), 101-115. DOI: 10.1006/enrs.2002.4352
4. Greger, JL (1992). Dietary and other sources of aluminum intake. *Aluminum in biology and medicine* , 26-49. doi:10.1002/9780470514306.ch3

5. Flaten, T. P. (2001). Aluminum as a risk factor in Alzheimer's disease, with emphasis on drinking water. *Brain research bulletin* , 55(2), 187-196. DOI: 10.1016/s0361-9230(01)00459-2
6. Ochmański, W., & Barabasz, W. (2000). Aluminum--occurrence and toxicity for organisms. Przegląd lekarski, 57(11), 665-668. PMID: 11293216
7. Soni, MG, White, SM, Flamm, WG, & Burdock, GA (2001). Safety evaluation of dietary aluminum. *Regulatory toxicology and pharmacology* , 33(1), 66-79. DOI: 10.1006/rtph.2000.1441
8. Saiyed, S.M., & Yokel, R.A. (2005). Aluminum content of some foods and food products in the USA, with aluminum food additives. *Food additives and contaminants* , 22(3), 234-244. DOI: 10.1080/02652030500073584
9. Bosch, AC, O'Neill, B., Sigge, GO, Kerwath, SE, & Hoffman, LC (2016). Heavy metals in marine fish meat and consumer health: a review. *Journal of the Science of Food and Agriculture* , 96(1), 32-48. DOI: 10.1002/jsfa.7360
10. Salvo, A., Cicero, N., Vadalà, R., Mottese, AF, Bua, D., Mallamace, D., ... & Dugo, G. (2016). Toxic and essential metals determination in commercial seafood: Paracentrotus lividus by ICP-MS. *Natural product research* , 30(6), 657-664. DOI: 10.1080/14786419.2015.1038261
11. Küpeli, T., Altundağ, H., & İmamoğlu, M. (2014). Assessment of trace element levels in muscle tissues of fish species collected from a river, stream, lake, and sea in Sakarya, Turkey. *The scientific world journal* , 2014. DOI: 10.1155/2014/496107
12. Greger, JL, Goetz, W., & Sullivan, D. (1985). Aluminum levels in foods cooked and stored in aluminum pans, trays and foil. *Journal of Food Protection* , 48(9), 772-777. DOI: 10.4315/0362-028X-48.9.772
13. Gonzalez-Weller, D., Gutiérrez, A.J., Rubio, C., Revert, C., & Hardisson, A. (2010). Dietary intake of aluminum in a Spanish population (Canary Islands). *Journal of agricultural and food chemistry* , 58(19), 10452-10457. DOI: 10.1021/jf102779t
14. Saiyed, S.M., & Yokel, R.A. (2005). Aluminum content of some foods and food products in the USA, with aluminum food additives. *Food additives and contaminants* , 22(3), 234-244. DOI: 10.1080/02652030500073584
15. Stahl, T., Taschan, H., & Brunn, H. (2011). Aluminum content of selected foods and food products. *Environmental Sciences Europe* , 23(1), 1-11. doi: 10.1186/2190-4715-23-37
16. Khan, N., Ryu, KY, Choi, JY, Nho, EY, Habte, G., Choi, H., ... & Kim, KS (2015). Determination of toxic heavy metals and speciation of arsenic in seaweeds from South Korea. *Food chemistry* , 169, 464-470. DOI: 10.1016/j.foodchem.2014.08.020
17. Cuciureanu, R., Urzică, A., Voitcu, M., & Antoniu, A. (2000). Assessment of daily aluminum intake by food consumption. *Revista Medico-Chirurgicala a Societatii de Medici si Naturalisti din Iasi* , 104(3), 107-112. PMID: 12089908
18. Klotz, K., Weistenhöfer, W., Neff, F., Hartwig, A., van Thriel, C., & Drexler, H. (2017). The health effects of aluminum exposure. *Deutsches Ärzteblatt International* , 114(39), 653. doi: 10.3238/arztebl.2017.0653
19. Kawahara, M., & Kato-Negishi, M. (2011). Link between aluminum and the pathogenesis of Alzheimer's disease: the integration of the aluminum and amyloid cascade hypotheses. *International journal of Alzheimer's disease* , 2011. doi: 10.4061/2011/276393
20. Morris, CM, Candy, JM, Oakley, AE, Taylor, GA, Mountfort, S., Bishop, H., ... & Edwardson, JA (1989). Comparison of the regional distribution of transferrin receptors and aluminum in the forebrain of chronic renal dialysis patients. *Journal of the neurological sciences* , 94(1-3), 295-306. DOI: 10.1016/0022-510x (89)90238-4
21. Malluche, HH (2002). Aluminum and bone disease in chronic renal failure. *Nephrology Dialysis Transplantation* , 17(suppl_2), 21-24. DOI: 10.1093/ndt/17.suppl_2.21
22. Kim, MS, & Clesceri, LS (2001). Aluminum exposure: A study of an effect on cellular growth rate. *Science of the total environment* , 278(1-3), 127-135. DOI: 10.1016/s0048-9697(00)00892-5

23. Giorgianni, CM, D'Arrigo, G., Brecciaroli, R., Abbate, A., Spatari, G., Tringali, MA, ... & Luca, AD (2014). Neurocognitive effects in welders exposed to aluminum. *Toxicology and industrial health* , 30(4), 347-356. DOI: 10.1177/0748233712456062
24. Nolan, CR, Califano, JR, & Butzin, CA (1990). Influence of calcium acetate or calcium citrate on intestinal aluminum absorption. *Kidney international* , 38(5), 937-941. DOI: 10.1038/ki.1990.294
25. Guo, CH, Chen, PC, Hsu, GSW, & Wang, CL (2013). Zinc supplementation alters plasma aluminum and selenium status of patients undergoing dialysis: a pilot study. *Nutrients* , 5(4), 1456-1470. doi:10.3390/nu5041456
26. Dordevic, D., Buchtova, H., Jancikova, S., Macharackova, B., Jarosova, M., Vitez, T., & Kushkevych, I. (2019). Aluminum contamination of food during culinary preparation: Case study with aluminum foil and consumers' preferences. *Food Science & Nutrition* , 7(10), 3349-3360. doi:10.1002/fsn3.1204
27. Inan-Eroglu, E., Gulec, A., & Ayaz, A. (2018). Determination of aluminum leaching into various baked meats with different types of foils by ICP-MS. *Journal of Food Processing and Preservation* , 42(12), e13771. doi:10.1111/jfpp.13771
28. Martinez, CS, Alterman, CD, Peçanha, FM, Vassallo, DV, Mello-Carpes, PB, Miguel, M., & Wiggers, GA (2017). Aluminum exposure at human dietary levels for 60 days reaches a threshold sufficient to promote memory impairment in rats. *Neurotoxicity research* , 31(1), 20-30. DOI: 10.1007/s12640-016-9656-y
29. Bondy, S.C. (2014). Prolonged exposure to low levels of aluminum leads to changes associated with brain aging and neurodegeneration. *Toxicology* , 315, 1-7. DOI: 10.1016/j.tox.2013.10.008
30. Duggan, JM, Dickeson, JE, Tynan, PF, Houghton, A., & Flynn, JE (1992). Aluminum beverage cans as a dietary source of aluminium. *Medical journal of Australia*, 156(9), 604-605. DOI: 10.5694/ j.1326-5377.1992.tb 121455.x
31. Fermo, P., Soddu, G., Miani, A., & Comite, V. (2020). Quantification of the aluminum content leached into foods baked using aluminum foil. *International Journal of Environmental Research and Public Health* , 17(22), 8357. doi: 10.3390/ijerph17228357
32. Igbokwe, IO, Igwenagu, E., & Igbokwe, N.A. (2019). Aluminum toxicosis: a review of toxic actions and effects. *Interdisciplinary toxicology* , 12(2), 45-70. doi:10.2478/intox-2019-0007

An extended HTML version of this article is available on the edaplus.info website.

Received 04.04.2022

Aluminum (Al) - importance for the body and health, where it is contained

Eliseeva Tatyana, editor-in-chief of the EdaPlus.info project

E-mail: eliseeva.t@edaplus.info