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## A Review of Heavy Metal Contamination in Commonly Consumed Food Items

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**ABSTRACT:** Heavy metals play an important role in the homeostasis of living cells. However, these elements induce several adverse environmental effects and toxicities, and therefore seriously affect living cells and organisms. In recent years, some heavy metal pollutants have been reported to cause harmful effects on crop quality, and thus affect both food security and human health. For example, chromium, cadmium, copper, lead, and mercury were detected in natural foods. Evidence suggests that these elements are environmental contaminants in natural foods. Consequently, this review highlights the risks of heavy metal contamination of the soil and food crops, and their impact on human health. The data were retrieved from different databases such as Science Direct, PubMed, Google scholar, and the Directory of Open Access Journals. Results show that vegetable and fruit crops grown in polluted soil accumulate higher levels of heavy metals than crops grown in unpolluted soil. Moreover, heavy metals in water, air, and soil can reduce the benefits of eating fruits and vegetables. A healthy diet requires a rational consumption of foods. Physical, chemical, and biological processes have been developed to reduce heavy metal concentration and bioavailability to reduce heavy metal aggregation in the ecosystem. However, mechanisms by which these heavy metals exhibit their action on human health are not well elucidated. In addition, the positive and negative effects of heavy metals are not very well established, suggesting the need for further investigation.

**KEYWORDS:** heavy metals, food security, human health, ecosystem, effects, crop quality, environment, pollution, diet

### I.INTRODUCTION

Metals such as arsenic, cadmium, lead and mercury are naturally occurring chemical compounds. They can be present at various levels in the environment, e.g. soil, water and atmosphere. Metals can also occur as residues in food because of their presence in the environment, as a result of human activities such as farming, industry or car exhausts or from contamination during food processing and storage. People can be exposed to these metals from the environment or by ingesting contaminated food or water. Their accumulation in the body can lead to harmful effects over time. EFSA has received requests from the European Commission or Member States to provide risk assessments on several metals as contaminants, including arsenic, cadmium, chromium, lead, mercury, nickel and uranium. This work is carried out by the Panel on Contaminants in the Food Chain (CONTAM Panel). EFSA also works closely with Member States and other data providers to collect data on occurrence of metals in food and feed.<sup>1</sup>

The principles of EU legislation on contaminants in food are contained in Regulation 315/93/EEC:

- Food containing a contaminant to an amount unacceptable from the public health viewpoint,<sup>2</sup> and in particular at a toxicological level, is not to be placed on the market.
- Contaminant levels must be kept as low as can reasonably be achieved following recommended good working practices.
- Maximum levels must be set for certain contaminants in order to protect public health.

Regulation EC 1881/2006 lays down maximum levels for certain contaminants in foodstuff, including lead, cadmium, mercury and inorganic tin. It does not cover radioactive substances. Regulation EC 333/2007 covers the methods of

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sampling and analysis for the official control of the maximum levels of these metals. Surveillance for residues of chemical elements in foods of animal origin is specified in Council Directive 96/23/EC.<sup>3</sup>

Take note of these 10 foods most susceptible to contamination with heavy metals. There may be ways to find high-quality sources with lower levels of these toxins, but what's most critical is to maintain a balanced diet. Shapiro recommends that these higher-risk foods shouldn't be eaten daily, in order to minimize the potential build-up of contaminants.<sup>4</sup>

## 1. Baby Food

No parent wants to find out that their child's food is hiding an alarming number of neurotoxins, but that's exactly what happened in 2013, when reports revealed popular baby food brands to contain well above the recommended limit for heavy metals, including "91 times the arsenic level, 177 times the lead level, 69 times the cadmium level, and 5 times the mercury level."

The dangers of heavy metals are most prevalent for young, developing children. So it's no wonder that the FDA needed to take action. The guidelines released this year aim to "result in significant reductions in exposures to lead from food while ensuring availability of nutritious foods."<sup>5</sup>

However, change takes time, and it's only a first step in ensuring the safety of baby food. "The guideline does not legally mandate any changes from the food and agricultural industries, so the effectiveness of this guideline is questionable," notes Shapiro.<sup>6</sup>

Until more restrictions are required by the agency, it's a challenge that parents will have to take on. You can start by feeding your child a wide range of high-quality foods and avoiding known formulas with toxic metals.

2. Fruit Juice : Think twice before you pour that refreshing glass of apple juice. The FDA has been targeting fruit juice as part of its "Closer to Zero" plan to reduce heavy metal exposure for babies and children. The draft guidelines published in April 2012 established the FDA's recommendation that apple juices should not exceed lead levels above 10 ppb, and other juices should not exceed 20 ppb.<sup>7</sup>

However, some experts say the recommended limit isn't low enough to protect children. Linda Birnbaum, Ph.D. and director of the National Institute of Environmental Health Sciences, told Consumer Reports that even juices with 1 ppb of lead or arsenic are still a concern: "It's clear from an abundance of research that there is no safe level for lead exposure."<sup>8</sup>

3. Rice grain is a staple for millions of people because it's widely available, filling, and relatively inexpensive. It's also a popular base for many cereals, which lots of kids consume daily. The FDA guidance aims to limit lead content in dry cereal to 20 ppb.

"Products made with rice, particularly cereals, were the top sources of heavy metals, especially inorganic arsenic," Consumer Reports noted in a 2013 study.

Rice crops absorb about 10 times more arsenic than other grains, according to the nonprofit consumer group. It typically accumulates on the outer layer of the rice, so brown rice contains more than white. But there are other grains you can substitute as better options, like buckwheat, millet, bulgur, barley, and farro.<sup>9</sup>

"Arsenic is in a huge proportion of the global rice supply," Dr. Falcone says. "At very low levels, humans can pretty much tolerate it, but when you're very young, that's when you're most sensitive."<sup>10</sup>

When you do eat rice, you can reduce around 30% of the arsenic contamination by rinsing the rice before cooking, as well as using a 6 to 1 ratio of water to rice when cooking. Consumer Reports also outlined a "7 points per week" system to help children and adults regulate how much arsenic they're taking in from rice on a regular basis.

## 4. Dark Chocolate

You don't usually have to feel guilty about indulging in a square of dark chocolate. The varieties with over 70% cacao are loaded with antioxidant-rich and anti-inflammatory flavanols that can help improve heart health, cognitive function, and blood pressure.

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Now there may be a reason to watch your intake of this better-for-you dessert<sup>11</sup>. In 2012, Consumer Reports found that there were dozens of popular dark chocolate products with levels of lead and cadmium that exceeded limits set by California, including items from Trader Joe's and Hershey's. From the study, they also identified a few "safer" dark chocolate bars with relatively lower levels of these toxic metals.

According to Consumer Reports, cadmium contaminates the cocoa bean in the soil, where the tree takes up the metal as it grows. Lead can be found on the outer shells of cacao pods, and as they are harvested, the beans themselves accumulate the lead from dust and dirt in the process.<sup>12</sup>

## 5. Protein Powder

When it's difficult to get enough of this building block in your food—especially for non-meat eaters—protein powders come to the rescue. But not all protein powders are created equal, and some come with the added risk of toxic metal exposure.

Commercial protein supplements, both whey and plant-based, were found to contain concerning amounts of lead levels in a 2014 study by the Clean Label Project. The study showed that some of the plant-based protein powders had twice the amount of lead, along with levels of arsenic, cadmium, and mercury.

The testing lab's director Sean Callan explained, "This could be due to the locations where the protein powder manufacturers' plant ingredients are sourced having contaminated soil. This is especially true in the United States where there may be a higher incidence of heavy metals in the soil of some regions."<sup>13</sup>

With a little bit of research, you can still find high-quality protein powders with fewer harmful ingredients.

## 6. Leafy Greens

A salad full of leafy greens is a great way to fit tons of vitamins and nutrients in your diet. But beware of a hidden downside to packing your bowl with these fiber-rich vegetables. They're traditionally grown in soil, and when the soil has traces of heavy metals, leafy greens like spinach and lettuce are prone to absorbing them.

According to Dr. Falcone, leafy brassica vegetables—think kale, cabbage, Brussel sprouts—are particularly efficient at taking up the contaminants. "Some plants are good at not accumulating contamination in water or soil. For brassica, [heavy metals] accumulate in the leaves," he says. "They're called hyperaccumulators, so they concentrate the components in the plant in a bioremediation process to take up the heavy metals from the soil to decrease its levels."<sup>14</sup>

Consumers have just started to find out just how much of the toxic metals can be found in their food sources. In December 2013, an effort by the nonprofit group As You Sow to "promote environmental and social corporate responsibility" revealed dangerous levels of cadmium in spinach sold by large retailers like Safeway, Trader Joe's, and Target.

The metal was present in standard and organic spinach products. As You Sow urges people to voice their concerns directly to companies, in order to push regulation changes for the better.<sup>15</sup>

## 7. Root Vegetables

Sweet potatoes and carrots are also susceptible to soil contamination. Root vegetables are considered at higher risk for containing heavy metals, according to Consumer Reports. Buying all-natural or organic doesn't make much of a difference, either, CNN Health reported, since the methods for organic farming also use soil and water.

The amount of toxic metals can be vastly inconsistent. CNN Health found that one sweet potato contained ten times more than a store-bought sweet potato puree, and it can be difficult to determine what factors affect the discrepancy.

It's still a good idea to incorporate these foods, because they do provide health benefits. "Carrots and sweet potatoes are sources of important nutrients like beta carotene, potassium, and fiber, and you can feed them to your child in rotation with other vegetables," said Consumer Reports nutritionist Amy Keating, RD. "What's key is eating a balance of healthy foods."<sup>16</sup>

## 8. Spices

We add flavors to our dishes to make eating more enjoyable. Some seasonings, like turmeric and ginger, even come with added health benefits. But there's a reason you may want to lay off the spices. Consumer Reports tested an array of

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products from large retailers and saw that nearly one-third had dangerous amounts of arsenic, lead, and cadmium. Fortunately, the majority of spices didn't exceed test limits, so it's not a sign to ditch your seasonings altogether—just to be cautious.<sup>17</sup>

You should also be on alert when evaluating supplements. Turmeric, for example, is available as an anti-inflammatory supplement, but since the FDA doesn't regulate these products, it can be challenging to know if you're getting a good one. Consumer Reports recommends looking for a third-party testing label to ensure it hasn't been contaminated with lead before you add it to your regimen.<sup>18</sup>

## 9. Fish

Despite its health advantages, most consumers are aware that fish can't be eaten daily. Because of pollution, a mercury compound called methylmercury accumulates in seafood sources in potentially dangerous amounts.

Mercury contamination passes through the fish food chain, originating in their food sources like algae, which readily absorbs the toxins in the water. It's not uncommon for people to have high blood mercury levels. One study showed that, out of 89 people in the U.S., 89% had excessive mercury in their blood, according to Healthline. The side effects of eating too much mercury include neurological impairments like hearing, vision, and coordination challenges and muscle weakness.

To reap the benefits of heart-healthy Omega-3s and protein found in seafood, avoid eating types of fish that accumulate mercury frequently (yellowtail, swordfish, tilefish) and opt for ones that tend to have lower levels of mercury (sockeye salmon, Atlantic herring, canned sardines).<sup>19</sup>

## 10. Bone Broth

The flavorful soup base is thought to have ample benefits, providing minerals, collagen, and protein to help with nutrition, gastrointestinal function, and weight maintenance.

But adding a cup of bone broth to your routine isn't without its risks. As the bones get simmered down to release all of the good iron and magnesium, you may also be infusing the stock with dangerous metal toxins.

Concerning amounts of lead can be sequestered in the bones of farm animals, which leaches out into the broth. A 2013 study found that, even in organic sources, lead could be seen at noticeably high levels in bone broth compared to the tap water with which it was cooked.

It's true that bone broth does wonders for your health, so if you want to incorporate it into your diet to support your musculoskeletal and digestive well-being, stick to drinking it in limited amounts.<sup>20</sup>

## II. DISCUSSION

The investigation of magnitude of heavy metal contamination and determined the carcinogenic as well as non-carcinogenic risks associated with selected food consumption. Commonly consumed varieties of rice, vegetables, and fish samples were analyzed to measure the concentrations of heavy metals such as cadmium, chromium, lead, arsenic, manganese, nickel, and zinc. These staple food items showed the greatest probabilities of heavy metal contamination in different phases of their production and marketing. Wide variations of metal concentrations were observed. Specifically, estimated daily intakes of arsenic and cadmium exceeded allowable daily intakes in all three food items.<sup>22</sup> Toxicity scores of the metals were evaluated, and a comprehensive risk assessment was conducted to quantify the risks associated with the daily food consumption. Except for cadmium and lead in vegetables, all the contaminants present in each food item posed significant levels of carcinogenic risks up to  $2.99 \times 10^{-3}$  compared to the EPA recommended carcinogenic risk level of  $1.0 \times 10^{-6}$ . Cadmium and arsenic intake due to rice consumption also posed unsafe levels of non-carcinogenic risks of 4.587 and 6.648, respectively, compared to the EPA recommended non-carcinogenic risk level of 1.0. Finally, a revised set of permissible limits was proposed for the heavy metals detected in the food items. Those permissible limits would ensure the risks associated with food consumption below the allowable carcinogenic and non-carcinogenic risk levels. Thus, this comprehensive approach would provide guidelines to formulate adequate control measures and regulatory limits of toxic metals in foods produced and marketed in India.<sup>23</sup>

You can get heavy metal poisoning by exposing yourself to heavy metals. Heavy metals form naturally within the Earth's crust. We interact with small amounts of heavy metals every day, like when you check the temperature of your

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thermometer, which uses mercury. Heavy metal poisoning occurs when metals get into your body. This can happen if you're exposed to a large amount of metal including:

- Eating a lot of food that contains metals (fish).
- Drinking water from older water supply systems.
- Working with metals on the job.
- Taking medications or supplements with high amounts of metallic elements.
- Handling metals or products made with a large amount of metal (like paint or pesticides) without using personal protective equipment.<sup>24</sup>

Most metals that cause poisoning are in a microscopic (molecular) form when they enter your body. They are so small, you won't be able to see them. Heavy metals can enter your body by:

- Absorbing into your skin.
- Breathing in or inhaling tiny metal molecules.
- Eating or drinking (ingesting) the metal from food or water.<sup>25</sup>

Heavy metal poisoning can affect anyone who has exposure to heavy metals. This most often affects people who:

- Drink water from pipes made of older metals (lead).
- Work with metals.
- Take more than the prescribed dosage of medicine or supplements that contain metal.
- Live in an environment with high air or water pollution.
- Eat a lot of foods that contain metal.
- Consume a non-edible product made with metal (paint).

Children are at a higher risk of heavy metal poisoning because their bodies are still developing and they are more sensitive to the harmful effects of heavy metals.<sup>26</sup>

The exact rate of occurrence is unknown, but in the United States, heavy metal poisoning is rare since it only affects people who have exposure to heavy metals. The number of people diagnosed with heavy metal poisoning decreased significantly over the last 20 years because of awareness and preventative measures to remove heavy metals from homes. Exposure to heavy metals can be dangerous to your health. While we use and interact with metals every day, certain heavy metals are toxic because the molecules that make up the metal damage or negatively interact with the cells in your body that are essential to keep your organs functioning.

Your body has small amounts of metals in it already, like iron, copper and zinc. These metals are important to keep your organs functioning. If you have too much metal accumulated within your body, it can damage your vital organs like your brain and liver.<sup>27</sup>

## III.RESULTS

Signs and symptoms vary for each type of metal and range in severity based on your body's exposure. Symptoms could include:

- Abdominal pain.
- Chills or a low body temperature.
- Dehydration.

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- Diarrhea.
- Feeling weak.
- Nausea or vomiting.
- A scratchy feeling in your throat.
- Numbness or prickly sensation in your hands and feet.<sup>28</sup>

Severe symptoms of heavy metal poisoning that can be life threatening include:

- Abnormal heartbeat (arrhythmia).
- Anemia.
- Brain damage and memory loss.
- Difficulty breathing.
- Kidney damage.
- Liver damage.
- Miscarriage in people who are pregnant.
- Risk of developing cancer.

If you experience severe symptoms after exposure to a heavy metal, visit the emergency room immediately.<sup>29</sup>

It can be difficult for providers to diagnose heavy metal poisoning because symptoms are similar to other conditions. Tell your provider if you know you had exposure to a toxic metal. After a physical exam, your provider will offer several tests to check for heavy metal poisoning including:

- Heavy metal blood test.
- Complete blood count (CBC).
- Electrocardiogram.
- Imaging tests like an X-ray.
- Kidney function tests.
- Liver function studies.
- Urine protein test.<sup>30</sup>

A heavy metal blood test, also known as a heavy metals panel or heavy metal toxicity test, looks at a small sample of your blood for the presence of metals. The test looks for common metals such as:

- Lead.
- Mercury.
- Arsenic.
- Cadmium.

The test can also look for less common metals including:

- Copper.
- Zinc.
- Aluminum.
- Thallium.

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The results of this test identify if you've had exposure to toxic metals and how much of that metal is in your body.<sup>31</sup>Treatment for heavy metal poisoning varies based on the type of metal that accumulated in your body. The goal of treatment is to remove the metal from your body. Treatment could include:

- Taking chelating agents to remove toxic metals from your body through your urine.
- Pumping your stomach (gastric lavage).
- Hemodialysis for kidney failure.
- Medicines to treat symptoms.

Some metals, like cadmium, don't have an effective treatment to remove it from your body. Studies are ongoing to find a treatment for cadmium poisoning. There are several drugs available to remove heavy metals from your body. These drugs are chelating agents that attract the metal to the components in the medicine, then pass the metal out of your body as waste in your urine.<sup>32</sup> Common chelating agents include:

- Dimercaprol.
- Dimercaptosuccinic acid (succimer).
- Ethylenediaminetetraacetic acid (EDTA).
- Penicillamine.

These chelating agents are usually given to people with severe heavy metal poisoning through an IV that places a small needle into your vein to slowly distribute the medicine into your body. Chelating agents can also attach to healthy metals and minerals in your body, so your provider will closely monitor how your body responds to treatment.<sup>33</sup>

Chelating agents are unsafe for people diagnosed with heart disease and kidney failure.

## IV. CONCLUSIONS

The amount of time between treatment and when you'll feel better depends on the amount of metal in your body that needs to be removed. After treatment begins, you could see symptoms lessen within a few hours and other cases may last several months with continuous treatment.

Treatment may be ongoing for people with severe symptoms that affect the function of their organs.<sup>34</sup>

You can reduce your risk of heavy metal poisoning by minimizing your exposure to heavy metals. You can do this by:

- Wearing personal protective equipment, like a mask and gloves, when working with heavy metals.
- Calling your local environmental protection agency to clean up any heavy metal spills.
- Limiting the amount of fish that contain metals (mercury) in your diet.
- Contacting your local health department, landlord or inspector to make sure you don't have any heavy metals in your home.<sup>35</sup>
- Washing your hands before you eat.
- Reading labels on products you purchase to see if they contain metals (baby food).<sup>36</sup>

If you live in an environment with high levels of pollution or unsafe drinking water, you are at risk of getting heavy metal poisoning again if your environment doesn't improve.<sup>37</sup>

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