Contaminant Threats - Are They Real?

Demystifying Common Fallacies
In The Dietary Supplement Industry

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With the advent of cGMPs and new regulations, manufacturers of dietary supplements and ingredients have been diligently working to comply. Products and raw materials are tested and verified, often using third-party laboratories and certifying bodies. However, there is a perception being built that this is still an unregulated industry. Such stereotyping has created significant image challenges for the industry. So when an industry watchdog, a media celebrity or even a competitor decides to mislead potential customers about the dangers of specific products, even if it is erroneous information, it becomes even more difficult to convince your customers that a product is safe. Using case studies, this white paper demystifies some common industry fallacies pertaining to contaminants such as “heavy metals” found in specific ingredients and products.

Arsenic in Seaweed-Based Products

The Misinformation

In a 2011 show, Dr. Mehmet Oz, the cardiac-surgeon-turned-television-personality, reported the results of an investigation of arsenic levels in apple juice. His show sent samples of 50 brands of apple juice to an independent laboratory. Based on these results, he claimed that apple juice contains worrying levels of arsenic. Since airing, Dr Oz’s comments have been labeled by many medical professionals, as well as the apple juice industry, as “extremely irresponsible.” In fact, the FDA sent a letter to the producer of the Dr. Oz Show five days before the show was to air, which warned that airing the show would be “irresponsible” and “misleading” because the testing was based solely on “total arsenic”.[1,2]

Reporting only “total arsenic” ignores a crucial piece of information–that there are two forms of arsenic and only one is considered unsafe. The laboratory used by Dr. Oz did not distinguish between harmful inorganic arsenic and harmless organic arsenic.

> *“The FDA believes that it would be irresponsible and misleading for The Dr. Oz Show to suggest that apple juice contains unsafe amounts of arsenic based solely on tests for total arsenic. Should The Dr. Oz Show choose to suggest that apple juice is unsafe because of the amounts of total arsenic found by EMSL Analytical, Inc.’s testing, the FDA will post this letter on its website.”*
>
> *From letter to Dr. Oz show from . . .*

Dr. Oz has since clarified he does not consider the arsenic in apple juice unsafe, and that he only wanted to point out that consumers need to be conscious of where food comes from. In some countries, like China for example, inorganic arsenic is still used in pesticides, which can get into fruit and vegetables grown there.[3] However, this clarification came too late, as the damage was already done. With over 3 million people regularly watching the Dr. Oz show, these claims kicked off media frenzy about arsenic in foods, from mainstream media outlets like ABC news to parent web sites and blogs, many of which just repeated the erroneous information.

Inorganic Versus Organic Arsenic

Arsenic occurs naturally in the environment in a variety of forms, being present in the soil and water for uptake by plants and animals.[4] Arsenic is the 20th most abundant element in the Earth's crust, 14th in the seawater, and 12th in the human body. It is a component of more than 245 minerals. It can also be released into the environment from some agricultural and industrial sources.[5]

Arsenic has no taste or smell and is usually part of chemical compounds. These compounds are divided into 2 groups:

- Inorganic compounds (combined with oxygen, iron, chlorine, and sulfur)
- Organic compounds (combined with carbon and other atoms)

Inorganic arsenic is a known human carcinogen — it is this form of arsenic that is linked with increased risks of cancer and other health effects. Inorganic arsenic compounds are found in industry, in building products, and in arsenic-contaminated water.[6]

Organic arsenic, on the other hand, is often found in foods, but is essentially harmless according to Donald Zink, Ph.D., Senior Science Advisor at the FDA's Center for Food Safety and Applied Nutrition.[7] Therefore, the key to understanding whether a product is potentially harmful due to arsenic levels is knowing the concentration of the two distinct forms of arsenic — inorganic versus organic. Laboratories routinely test for arsenic in foods and supplements, but the results are often reported as "total arsenic" (combination of organic and inorganic) and do not distinguish between the essentially nontoxic organic forms of arsenic and the harmful inorganic forms of arsenic. High "total arsenic" does not always translate to an unsafe product as inorganic arsenic species found in food typically account for no more than 1 to 3 percent of the total arsenic present, while the nontoxic organic arsenic makes up the rest.[8]

Distinguishing from the two forms is exactly what the FDA does when there is a concern over arsenic levels in a specific product. According to Dr. Zink:

> *It would be inappropriate to draw conclusions about the safety of a product based on the total arsenic level. When the FDA wants to determine if a food has unsafe levels of arsenic, we test the food specifically for the harmful, inorganic forms of arsenic. In fact, organic arsenic can make up the bulk of total arsenic in some foods. If you want to know if there are harmful amounts of arsenic in the sample, you must test specifically for inorganic arsenic."* [4]

Following the apple juice scare, many other products were being scrutinized for their arsenic content, such as rice and processed foods made with rice, poultry, grape juice, and marine foods such as seafood and seaweed. Seafood and seaweeds have been particularly singled out because they are high in total arsenic. Marine products are known to contain naturally–occurring levels of organic and inorganic arsenic. However, the inorganic arsenic levels are low and safe.

Seaweeds are a commonly used dietary supplement ingredient, offering unique nutrition and health benefits. The products sold by reputable companies and brands should not be considered in any way to be a safety risk. In the United Kingdom, for example, where many seaweed products are harvested, the Arsenic in Food Regulations (SI 1959 no. 831) lay down a general limit of 1 ppm (part per million) for total arsenic in food.[9] However, this does not apply to fish and edible seaweed, because they primarily contain two forms of nontoxic organic arsenic, arsenobetaine and arsenocholine, which are common substances in marine biological systems. Although arsenobetaine is bioavailable to humans, it is not metabolized and is rapidly excreted unchanged in urine.[10] Consequently, arsenobetaine is widely assumed to be of no toxicological concern.[11,12,13] Arsenocholine is chemically similar to arsenobetaine, and is also considered to be ''essentially nontoxic''.[14,15] Levels of the harmful inorganic arsenic in seaweed products are extremely low, and well within the safe regulatory levels also set by the FDA (less than 1 ppm).

The confusion resulting from only measuring total arsenic, and not specifically inorganic arsenic, is as evident in seaweed as it was in apple juice. A study in 2007 reported findings from a case study involving a possible link between arsenic toxicity and the ingestion of a kelp-based supplement.[16] A review of this study, however, concluded that it "inappropriately relied on total arsenic data to link arsenic exposure to se"[17] when only inorganic arsenic contributes any risk.

As with land-plants and animals, the levels of potential contaminants that may be present in seaweed reflects the environment in which they were grown. Knowing the type of seaweed and its origin is as important in seaweeds as it is in all foods. Since seaweeds are not as well established in the market as other foods, this knowledge is perhaps even more important.

For example, many Japanese types of seaweed have been linked to high arsenic levels due to their growing conditions.[18] Other sources, however, such as VitaKelp® seaweeds are harvested in Grade-A pristine waters around the Scottish Outer Hebrides in the North Atlantic Ocean, with water quality monitored by the Scottish Environmental Protection Agency. All batches of VitaKelp® are tested for inorganic arsenic by accredited independent laboratories, and are all well below regulatory maximum of 1 part per million.

Setting the Record Straight

While the word arsenic itself may have a scary connotation to the consumer, not all arsenic is harmful. Organic arsenic compounds, which are naturally-occurring and found in many foods, are considered nontoxic. Several organic arsenicals found in seaweeds, such as arsenobetaine and arsenocholine, have been studied by several researchers and have been found to be essentially nontoxic.

Aluminum in Chlorella

The Misinformation

On February 19, 2013, an article appeared on a popular natural-products industry website. In it, the author reports that he performed an informal test on various chlorella sources and their heavy metal content. The article reports that “chlorella from China was consistently more contaminated with metals than any other source.”

The average metals contamination found in the lab tests across the three sources from China were reported below:

- Aluminum: 29 ppm
- Arsenic: 0.89 ppm (inorganic versus organic arsenic not specified)
- Cadmium: 0.17 ppm
- Lead: 0.27 ppm

The levels of arsenic, cadmium or lead are not a concern to the author. However, what does concern him is the 29 ppm of aluminum found in the chlorella. The author of the article then recommends a “Clean Chlorella” product available through the website’s store because “I would never sell chlorella grown in China because I didn't want my readers eating 29 ppm of aluminum.”

Two key issues in this article are erroneous, yet the misinformation was repeated on a variety of other websites. First, aluminum is not considered a toxic heavy metal. Second, one cannot “eat 29 ppm of aluminum.” Parts per million (ppm) is a percentage – if put into a unit it would be mg aluminum per kg (mg/kg) of the substance or microgram per gram (mcg/g). Since ppm is a percentage, to determine the amount of aluminum an individual might ingest from supplementing with chlorella, the dosage must be considered. The recommended 3 gram dosage of chlorella actually provides very little dietary aluminum.

Is Aluminum a Toxic “Heavy Metal”?

While there is no official definition of a heavy metal, this term is often used to describe metals that have some level of toxicity.[19] Heavy metals are also sometimes defined as elements with metallic properties such as nickel and copper. Many other metals with “metallic properties” such as copper, iron and zinc are essential to human nutrition. In the dietary supplement industry, “heavy metals” are almost always characterized as the toxic metals lead, mercury, cadmium and inorganic arsenic. Products are routinely tested for these four elements, most often to guarantee meeting California’s Prop 65 levels. Prop 65 lists lead, cadmium, mercury and arsenic (specifically only inorganic

arsenic compounds) as potential carcinogens or causing reproductive toxicity. There are more than 200 other chemicals listed in the Prop 65 list and this list is considered to be the most stringent list of contaminating chemicals in the industry. Aluminum is not one the Proposition 65 list.

The chart below is from the USP (United States Pharmacopeia), with corresponding limits allowed for all metals, even those nutritionally required by humans. Oral limits for aluminum are higher than the nutrients zinc, strontium, iron, manganese and boron.

Element	Oral Permitted Daily Exposure for Dosage Forms, µg/day	USP Oral Limit, µg/g	USP Parenteral Limit, µg/g
Aluminum (Al)	50,000	5000	500
Antimony (Sb)	20	2	0.2
Arsenic (As)	15	1.5	0.15
Beryllium (Be)	100	10	1
Boron (B)	10,000	1000	100
Cadmium (Cd)	25	2.5	0.25
Chromium (Cr)	150	15	1.5
Cobalt (Co)	1000	100	10
Copper (Cu)	500	50	5
Indium (In)	100	10	1
Iridium (Ir)	100	10	1
Iron (Fe)	15,000	1500	150
Lead (Pb)	10[b]	1	0.1
Lithium (Li)	600	60	6
Magnesium (Mg)	[c]	[c]	[c]
Manganese (Mn)	7000	700	70
Mercury (Hg)	15	1.5	0.15
Molybdenum (Mo)	250	25	2.5
Nickel (Ni)	1000	100	10
Osmium (Os)	100	10	1
Palladium (Pd)	100	10	1
Platinum (Pt)	100	10	1
Rhodium (Rh)	100	10	1
Rubidium (Rb)	[c]	[c]	[c]
Ruthenium (Ru)	100	10	1
Selenium (Se)	250	25	2.5
Strontium (Sr)	30,000	3000	300
Thallium (Tl)	4	0.4	0.04
Tin (Sn)	30,000	3000	300
Tungsten (W)	375	37.5	3.8
Zinc (Zn)	15,000	1500	150

[a] Some of the limits in this table were calculated using the criteria given in the EMEA *Guideline on the Specification Limits for Residues of Metal Catalysts*, available at: http://www.emea.europa.eu/pdfs/human/swp/444600.pdf, accessed 25 March 2008.

[b] Limit for lead calculated from the FDA limit for bottled drinking water: 5 µg/L assuming consumption of 2 L/day.
[c] Under deliberation.

The FDA does not regulate aluminum levels in foods. They do, however, regulate the aluminum content of small- and large-volume parenteral drug products used in total parenteral nutrition therapy (intravenous nutrition) and it must not exceed 25 micrograms per liter.[20] The European Food Safety Authority (EFSA) set the weekly aluminum intake to 1 mg/kg body weight in 2008. This equates to 70 mg per week for a 70 kg person.[21]

Dietary Aluminum

Aluminum is the third most abundant element in the Earth's crust and the most abundant metal. Dietary aluminum is ubiquitous–we are constantly exposed to aluminum. Our food comes in contact with aluminum from aluminum foil and aluminum cookware. We drink sodas, juice and beer from beverage cans made from 92-99% aluminum.

Aluminum is also present in foods naturally or from the use of aluminum-containing food additives. The use of aluminum cookware, utensils, and wrappings can increase the amount of aluminum in food; however, the magnitude of this increase is generally not of practical importance. Foods naturally high in aluminum include potatoes (1 mg per serving) and spinach (1 mg per serving).[22] Tea (14-67 ppm), cocoa (80-312 ppm), and flour (1-19 ppm)[21] have also been reported to have high aluminum content. Infant formula may be high in aluminum if it contains aluminum-based food additives.[23]

According to the World Health Organization, aluminum salts are widely used in water treatment as a coagulant to reduce organic matter. U.S. water contains an average of 160 micrograms per liter.[24] The Environmental Protection Agency has specified a Secondary Maximum Contaminant Levels (SMCL) for aluminum. SMCLs apply to contaminants in drinking water that adversely affect its odor, taste or appearance and consequently cause a substantial number of persons to discontinue its use. SMCLs are not based on any direct adverse health effects associated with the contaminant itself. SMCLs are also considered desirable goals and are not federally enforceable. The SMCL level for aluminum is 50-200 micrograms/per liter for aluminum.

It has been reported that approximately 95% of an aluminum load from diet is eliminated renally. In healthy subjects, only 0.3% of orally administered aluminum is absorbed via the GI tract, followed by effective elimination by the kidneys. It is only when the GI barrier is bypassed, such as through intravenous infusion or in the presence of advanced renal dysfunction, that aluminum has the potential to accumulate.[25]

A 2013 published review reiterates that humans have several mechanisms to prevent significant absorption of aluminum and to aid its elimination; therefore, the vast majority of the population is not at risk for aluminum toxicity. This review also points out that when protective gastrointestinal mechanisms are bypassed (for example, parenteral/IV fluids), renal function is impaired and aluminum has the potential to accumulate. When exposure is high (for example, long-term parenteral nutrition solutions), or when renal function is impaired, aluminum is prone to accumulate in the body, resulting in the potential for neurological problems, metabolic bone disease, dyslipemia and even genotoxic activity.[26] Therefore, people with diminished kidney function have higher risk of aluminum toxicity. For this reason, aluminum levels in dialysate (the solution of chemicals used in dialysis) is also regularly monitored and FDA has limits for these products.

Setting the Record Straight

The recommended dosage for Chlorella is usually 3 grams per day. At 29 ppm, that equates to 87 micrograms of aluminum. How does that compare to the maximum levels for aluminum as advised by various regulatory bodies? Exposure to 87 micrograms per day is:

1. **575 times below the 50 milligram daily exposure limit** as listed by the USP (50,000 micrograms or 50 milligrams per day). An individual would have to consume a dosage of 1.7 kilograms of chlorella in one day to meet the 50 mg limit. It is also important to note that oral limits for aluminum are higher than any other metal listed in the USP chart.
2. **Over 100 times lower than the EFSA maximum level** of 1 mg/kg body weight weekly aluminum intake (this equates to 70 mg per week for a 70 kg person). One week of chlorella supplementation of 3 grams per day would provide only 0.6 mg of aluminum.
3. **Roughly one-half of the aluminum an individual would consume if they drank only 1 liter of water per day** based on average aluminum levels of water in the U.S. (160 micrograms/liter).

Aluminum toxicity is a concern for individuals on prolonged parenteral nutrition therapy and individuals with renal impairment. The amount of aluminum found in chlorella is lower than found in many foods and drinking water and does not pose a health threat. It also falls well below any regulatory agencies' "maximum" allowable level (EFSA, USP, EPA).

Conclusion

Reports of contaminations in dietary supplements have been the bane of the industry since its inception. While there is no doubt that there have been contamination issues that were real and dangerous (such as steroids contamination), many issues have been blown out of proportion. For instance, a 2010 GAO report stated that they found trace amounts of contaminants in 37 out of 40 herbal products tested, but that they posed no acute toxicity hazards. In fact, the GAO even stated FDA and EPA officials also did not express concern as these levels did not exceed any FDA or EPA regulations.[27] What made the news and the blogosphere was the truncated version– that GAO found contaminants in dietary supplements, period.

With more stringent cGMPs, contaminants found in dietary supplements have hopefully become a rarity. However, years of this type of negative press has tainted the industry. That is why it is so surprising when industry insiders use similar scare tactics. All manufacturers should be careful about using negative campaigns about contaminations to advance their own products, as they can only backfire by tarnishing the industry further. To avoid being the victim of misinformation, it pays to be very proactive, including proper analysis, safety assessment and consumer education.

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