

Taboo Food Combinations (Part 2)

Last month we looked at a well-known taboo food combination, persimmon and crabs. This month we will look into a food combination so deadly that an entire movie plot was based on it (drumroll please): shrimp and vitamin C. Actually since vitamin C is not technically a “food”, the adverse effect is probably better labeled as a food-drug interaction or contraindication for vitamin C, but I’ll let it slide.

In the 2008 movie “[Deadly Delicious](#)”, the protagonist was served 7 [specially designed meals](#). Each meal had its specific combinatorial effect, and the last (and deadliest) one was shrimp and vitamin C. The claim is that shrimp contains arsenic, which is transformed into a more toxic form by vitamin C. Quite an innovative and sneaky way to poison our cheating protagonist. Before seeing if it is possible, let’s look at some basic toxicology concepts.

A Short Primer on Toxicity

The first concept in toxicity: *everything is toxic*. Yes, you read that right. Even water is toxic in large doses, and many have died in [water drinking contests](#). The 2nd key concept: *the dose makes the poison*. There is a dose above which the mundane become toxic (e.g., water), and a dose beneath which the most vicious toxicant has no effect (e.g., a few molecules of Botulinum toxin).

For example, a mother’s breast milk demonstrably [contains heavy metals](#). It would be misleading, but technically accurate, for a headline to read “Mothers Intentionally Feed Carcinogenic Heavy Metals to Babies”. Yet breast milk [remains](#) the best food for infants, because the concentration of heavy metals are usually low enough to dismiss, and the benefits far outweigh the risks. The dose makes the poison.

A common misconception is that if something is labeled “toxic”, all forms of it are equally toxic. Take mercury as an example. There is elemental mercury (typically a liquid metal), inorganic mercury, and organic mercury. Dimethylmercury is an organic mercury, and one of the [strongest](#) known neurotoxins – the slightest amount could kill you. Liquid elemental mercury, on the other hand, is poorly absorbed by the skin and digestive tract, and comparatively far less toxic. In fact, people have [injected liquid mercury](#) (as an aphrodisiac), and in [one case](#), intentionally drank 3kg(!) of mercury. Both came out relatively unscathed. Same element, yet wildly different toxic profiles. A word of caution before looking up the actual case reports online – some things cannot be unseen. You were warned.

Similar to mercury, arsenic also comes in different flavors, and vary wildly in terms of toxicity. Inorganic arsenic comes in two main forms (trivalent and pentavalent) and are both very toxic. On the other hand, organic arsenic is [readily excreted](#) and usually [considered harmless](#) to humans.

A shaky foundation

The origins of the shrimp and vitamin C myth probably came from a bungled Chicago Tribune [report](#) of a 1984 [study](#), which studied arsenic in chicks, not seafood. It studied how *inorganic* arsenic may change from [pentavalent](#) to [trivalent](#) form under a reducing agent such as vitamin C. Unfortunately, the [vast majority](#) of arsenic in shrimp is [arsenobetaine](#), an *organic* arsenic compound that is considered non-toxic.

How much of the shrimp arsenic is in the toxic form? According to a 1997 study by the US EPA, the total amount of harmful inorganic arsenic in shrimp is [likely under](#) 3%, and according to more recent surveys, less than 1%. So, arsenic does exist in shrimp, but mostly in a harmless form. Even if Vitamin C changes

the form of what little harmful inorganic arsenic there is, the increase in toxicity is still negligible - in the same sense that two spoons of salt instead of one do not make a pond noticeably saltier.

How much shrimp is needed?

Let's look at the worst case scenario, and see how much shrimp is needed to be lethal. Assuming a 70kg man, a low 10mg/kg lethal dose, a batch of seafood exceptionally high in both total arsenic (100ppm) and inorganic arsenic (5%), the amount of shrimp needed to die from arsenic poisoning comes out to just over 100kg of shrimp. For that amount, it is safe to say that one would likely die from mechanical, not chemical causes - if not from eating, then certainly from passing.

Conclusion

The “deadly” combination of shrimp and Vitamin C has the ingredients of a good myth. It has a compelling narrative right on the edge of plausibility, a scary and vaguely familiar toxic compound, and an ounce of truth stretched beyond recognition. Yet like most myths, it also crumbles under close inspection. There is no real arsenic risk eating shrimp and vitamin C – you probably get more inorganic arsenic from the rice you eat it with, especially the “healthy” [brown rice](#).

This myth is sold on fear, which is used to sell almost everything: products, services, education, political views, software, anatomy enhancing devices, relationships, even bigotry. We are constantly bombarded with information about everything being “toxic” – heavy metals, carcinogens, preservatives, and scary sounding chemicals. In fact, we often share the misinformation on social media, with good intentions but little thought. These scare stories feed on our basic survival instinct of fear and dichotomous black-and-white worldview, i.e., if something is toxic, then ANY amount of it is toxic. Reality, of course, is more nuanced.

Life is already too complicated to worry about made up risks. Before instinctively pressing the “share” button on the latest toxic scare, we should all pause and give it some thought. A little bit of skepticism goes a long way towards stopping the spread of misinformation.

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<http://www.meetup.com/Skeptics-in-the-Pub-Dongguan/>

References:

1. [Deadly Delicious \(2008\)](#), Baidu Baike
2. [双食记菜谱](#), 豆瓣电影
3. [Arsenic Pentoxide Material Safety Data Sheet](#) (MSDS)
4. [Arsenic Trioxide Material Safety Data Sheet](#) (MSDS)
5. [Hold Your Wee for a Wii Contest](#)
6. [Median Lethal Dose \(LD50\)](#), Wikipedia
7. [Dimethylmercury and mercury poisoning](#)
8. [Intravenous injection of elemental mercury: A report of two cases](#), PubMed – WARNING, GRAPHIC

9. [Massive oral ingestion of elemental mercury](#), PubMed
10. [Borak J, Hosgood HD: Seafood Arsenic: Implications for human risk assessment](#), ScienceDirect
11. [Information on arsenic in food](#), Pediatric Environmental Health Specialty Units
12. [Arsenic Poisoning](#), MedicineNet.com
13. [Vitamin C Doses, Shellfish Don't Mix](#), Chicago Tribune
14. [Arsenobetaine](#), Wikipedia
15. [Arsenic and fish consumption](#), U.S. Environmental Protection Agency
16. [Chemical Biomarkers of Human Breast Milk Pollution](#), PubMed
17. [Does Mother's Milk Transfer Environmental Toxins to Breast-Feeding Babies?](#), Scientific American
18. [How much arsenic is in your rice?](#), Consumer Reports