Analysis of 17 elements in the top 10 most consumed seafoods in the US

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Abstract

A sample set representing the top ten most consumed seafoods in the US (according to the National Fisheries Institute) was collected from three US cities in 2018. Results of arsenic speciation analysis of these samples have been reported, and this current work expands on that study, with data on total arsenic as well as 16 other elements. FDA's Elemental Analysis Manual Method 4.7 is a multi-lab validated method (for Cr, Mn, Ni, Cu, Zn, As, Se, Mo, Cd, Hg, Pb) which has recently been single-lab validated for an additional 6 elements (V, Co, Sr, Sn, Tl, U). This survey includes these additional elements, providing a further demonstration of the suitability of the expanded method. In shrimp and finfish, V, Co, Mo, Cd, Sn, Pb, Tl and U were not detected above 50 ng/g wet weight. Clams were notably higher in Cr, Co, Ni, Cd and Pb relative to other surveyed seafood products. These and other findings will be presented.

Introduction

According to FDA, seafood is an important source of protein, omega-3 fats, vitamin B12 and vitamin D, among other nutrients[1]. However, seafood is also a known source of exposure to mercury and arsenic. In fact, literature searches for papers about elements in seafood bring up almost exclusively analyses of these two elements, along with iodine in seaweed. Beyond those seafoods analyzed as part of FDA's Total Diet Study project (canned tuna, catfish, salmon, shrimp),[2] information on the content of other elements in seafood is limited.

A method for analysis of arsenic species in seafood was recently applied to a set of samples representing the Top Ten most commonly consumed seafoods in the US[3] (according the National Fisheries Institute's annual Top Ten list), [4] with results showing inorganic concentrations were consistently low. To our knowledge, no similar survey had previously been conducted. Likewise, it seems no similar survey of other toxic or trace nutrient elements has been conducted, either. The top ten products account for nearly 90% of seafood consumed in the US, so by analyzing the most consumed seafoods and collecting sample sets from several cities, we hoped to capture a snapshot of elements Americans might be exposed to from seafood consumption.

[1] https://www.fda.gov/food/consumers/advice-about-eating-fish
[2] https://www.fda.gov/food/science-research-food/total-diet-study
[3] J. Agric. Food Chem. 2019, 67, 8253−8267
[4] https://www.aboutseafood.com/about/top-ten-list-for-seafood-consumption/

Materials and Methods

FDA's Elemental Analysis Manual (EAM) method 4.7 is multi-laboratory validated for the analysis of As, Cd, Pb, Hg, Cr, Cu, Zn, Se, Cr, Mn and Ni in food. More recently, single lab validation has been performed to expand EAM 4.7 to include V, Sr, Tl, U, Sn and Co. This expanded version of EAM 4.7 was used for this work.

Sample collection: Samples were collected from supermarkets near College Park, MD, Lenexa, KS, and Alameda, CA. CA and KS samples were shipped frozen/on ice to College Park. Where possible, more than one type of a product was collected (e.g. canned pink salmon, fresh Atlantic salmon) to account for diversity in the marketplace.

Sample preparation: Inedible tissues (shells, bones, skin) were removed. Breading/batter was removed from frozen fried fish portions. Remaining tissues were homogenized to thick pastes in a Robocoupe Blixer or Retsch GM200 mills and transferred to polypropylene bottles for storage at -4 ºC.

Digestion: Microwave-assisted digestion was performed using a MARS 6 (CEM) system. ~0.5 g portions of each sample were transferred to Xpress vessels along with 8 mL of nitric acid (Optima grade, Fisher Scientific) and 1 mL of hydrogen peroxide (Optima grade, Fisher Scientific).

Analysis: Solutions were analyzed using an Agilent 7700 ICP-MS according to EAM 4.7 expanded to quantitate V, Sr, Tl, U, Sn and Co.

2018	
Seafood type	**pounds**
shrimp	4.6
salmon	2.55
can tuna	2.1
tilapia	1.11
Alaska pollock	0.77
pangasius (swai)	0.63
cod	0.62
catfish	0.56
crab	0.52
clams	0.32
top ten sum	13.78
total per capita consumption	16.1
top ten % of total	86%

Figure 1. National Fisheries Institute list of ten most consumed seafoods in the US for 2018. Multiple species of shrimp, salmon, crab and clams were collected (also fresh/frozen/canned), reflecting availability in stores. DNA barcoding was used to confirm accurate labeling of products.

Results and Discussion

Ten of the 17 elements were detected at relatively low concentrations: Uranium- <40 ng/g, Thallium- <10 ng/g, Lead- <100 ng/g (<20 ng/g except for clams), Molybdenum- <130 ng/g (<40 except for clams), Chromium- <200 ng/g, Cobalt- <150 ng/g, Cadmium- <140 ng/g, Vanadium- <250 ng/g (<40 ng/g except for clams), Tin- <225 ng/g (<110ng/g except for crab), Nickel- <300 ng/g (except one clam sample at 1550 ng/g.

In general, freshwater fish (pangasius/swai, tilapia and catfish) had lower levels of toxic elements. Shrimp, clams or crab had the highest concentrations for most targeted elements. Canned tuna was highest in mercury (291 ng/g maximum), though still well below the 1 µg/g action level for methylmercury.

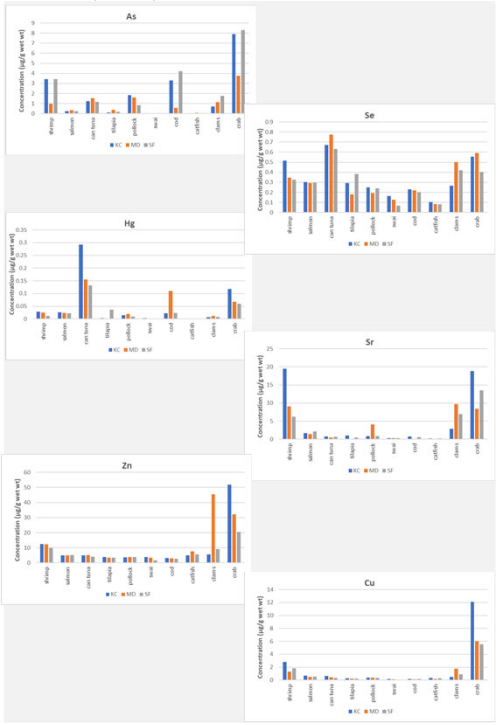
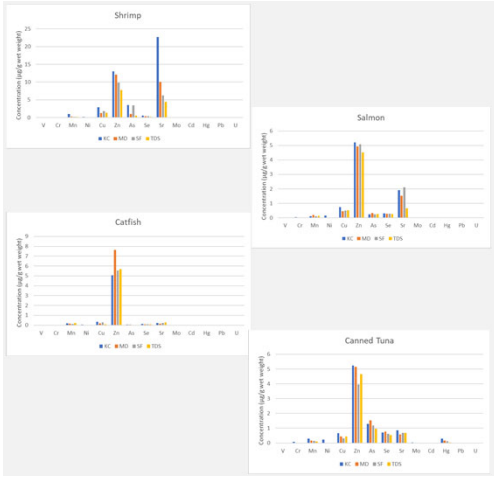


Figure 2. Charts showing results for selected elements in each of the top ten seafoods. Note that products including crab, clam, salmon, tuna and shrimp may comprise more than one species.

Figure 3. Charts showing regional results from this study alongside Total Diet Study data for the same products



Conclusion

- Most of the elements analyzed were detected at negligibly low concentrations
- Tuna had the highest concentration of Hg (Total Hg well below action levels for MeHg)
- Fresh water fish (tilapia, swai, catfish) have relatively lower concentrations of toxic elements (As, Pb, Hg, Cd)
- Crabs, clams and shrimp had the highest concentrations of Zn, Cu, Sr, As, and Mn
- Element concentrations were quite similar, regardless of collection region