Title: Development of a Method to Estimate *De Minimis* Levels for Metals in Meat and Poultry

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ABSTRACT

The Food Safety and Inspection Service (FSIS) conducted a dietary exposure assessment to determine if consumption levels from FSIS-regulated products might pose a potential adverse health outcome. The assessment used data from the National Residue Program (NRP) and examined the identified mean and maximum concentrations of each metal from the muscle tissues of each of the animal classes sampled (bovine, porcine, chicken, and turkey) from 2012 to 2015. For many years, FSIS has monitored meat, poultry and egg products for chemical residues through the NRP. Along with lead and cadmium which have been quantified since 2003, FSIS began testing for other trace elements, including cobalt, manganese, molybdenum, and selenium. These metals are essential dietary micro-nutrients; however, excessive dietary intake of these metals could pose a public health risk. The results from this assessment showed that levels of these metals found in FSIS-regulated commodities and consumed by the population are below 100% of the respective Health-Based Guideline Value (HBGV) of each metal. Based on this assessment, we developed a method to estimate the concentration of each metal that would result in consumption of 100% of the HBGV from each animal class. These estimates could be considered a level of no public health concern, or *de minimis*, if consumption of the mean level of the metal via FSIS-regulated product occurred chronically. A comparison of the concentrations identified via NRP sampling and the estimated *de minimis* levels were below a level that would pose an adverse health outcome. We will be incorporating consumption rates of each metal harbored in non-FSIS-regulated food product to allocate the *de minimis* level to FSIS-regulated product accordingly. These approaches will allow FSIS to compare the concentrations of each metal harbored in each animal class to a level that would not pose a health risk to consumers.

USDA

United States Department of Agriculture

One Team, One Purpose

Food Safety and Inspection Service

Protecting Public Health and Preventing Foodborne Illness

Food Safety and Inspection Service:

Presence of Metals in Various Food Products

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Food Safety and Inspection Service:

Outline

- Introduction
- Background
  - Food Safety and Inspection Service
    - National Residue Program
  - Food and Drug Administration
    - Total Diet Study
- Data from Regulatory Agencies

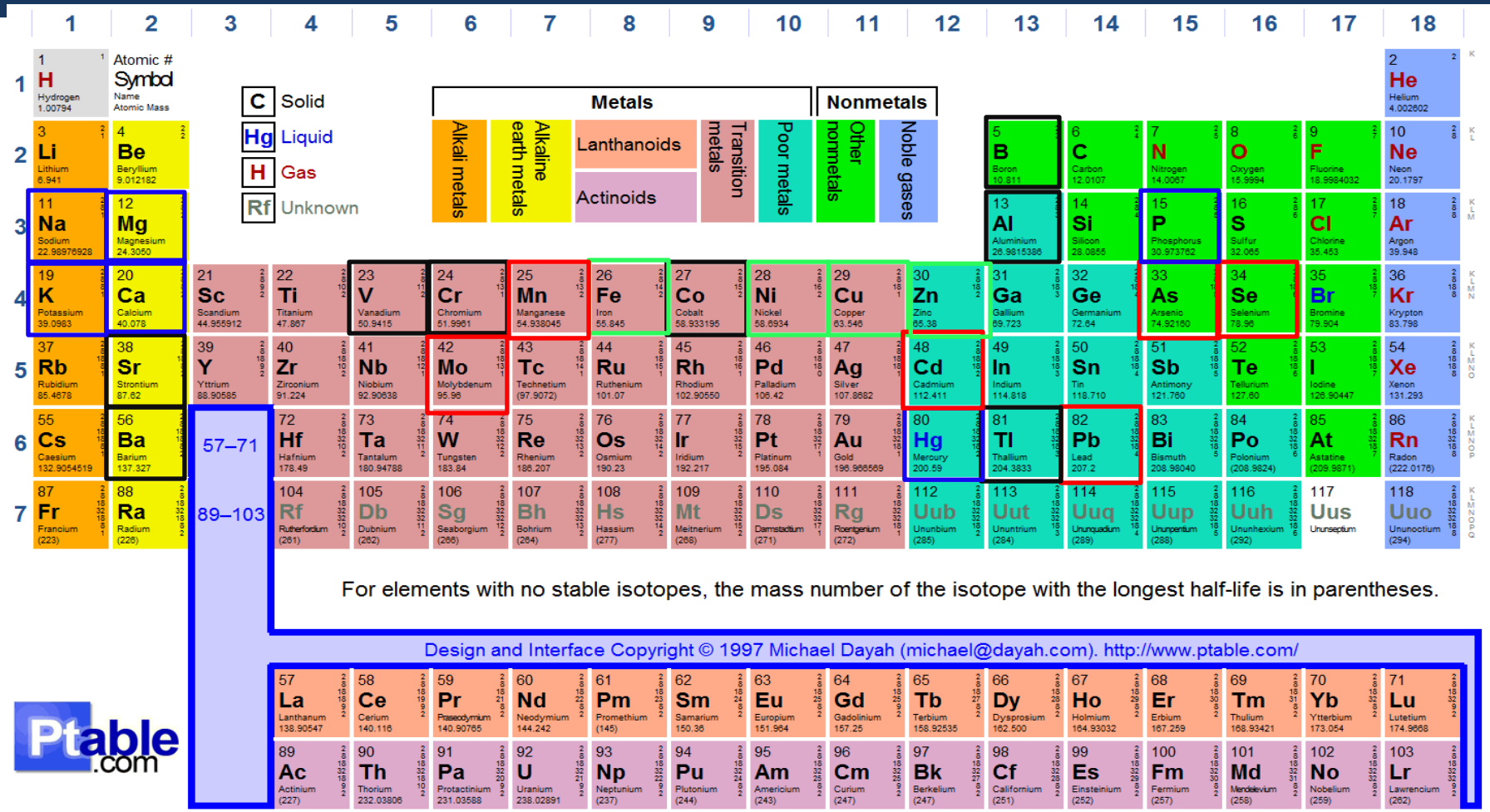
Food Safety and Inspection Service:

Data Disclaimer

- Data from FDA and FSIS sampling.
- Is publically available from the FSIS and FDA website.
- Metals chosen based on the high sensitivity of the methods used by the FSIS labs.

Food Safety and Inspection Service:

Periodic Table of Elements



FSIS

FSIS/ FDA

FDA

Data Presented Here

Food Safety and Inspection Service:

Metals in Foods

- Arsenic (As) in rice, chicken, wine (distributed through plants or metabolite of veterinary drug)
- Methyl mercury (MeHg) in fish (Minamata Bay, Japan)
- Cadmium (Cd) in leafy vegetables
- Lead (Pb) in wine (used as sweetener in the past)

Food Safety and Inspection Service:

Sources of Metals in Foods

- Human Exposure
  - Diet
- Animal Exposure
  - Animal Feed
  - Veterinary Drugs
  - Environment
    - Soil
    - Water
    - Air
- Plant Exposure
  - Soil

Food Safety and Inspection Service:

FSIS

- Public Health Agency within the USDA responsible for ensuring that the nation's commercial supply of meat, poultry, and egg products is safe, wholesome, and correctly labeled and packaged.

Food Safety and Inspection Service:

National Residue Program (NRP)

- Established in 1967, the NRP protects the nation from chemical hazards that might be in meat and poultry products.

- Analyzes various tissues for the presence of trace elements.
  - Tier 1 sampling - A certain number of muscle tissue samples are scheduled and collected randomly.
  - Tier 2 sampling - Public Health Veterinarians select animals for sampling based on professional judgment.

Food Safety and Inspection Service:

FSIS Metals Sampling

- Atomic Absorption Spectroscopy: As
- Inductively Coupled Plasma - Mass Spectrometry (ICP-MS): Cd, Cobalt (Co), Manganese (Mn), Molybdenum (Mo), Pb, Selenium (Se), Thallium (Tl)
- Inductively Coupled Plasma – Optical Emission Spectrometry (ICP-OES): Aluminum (Al), Barium (Ba), Boron (B), Chromium (Cr), Copper (Cu), Iron (Fe), Nickel (Ni), Strontium (Sr), Vanadium (V), Zinc (Zn)

Food Safety and Inspection Service:

Food and Drug Administration

- Protects the public health by assuring that foods, other than meat, poultry, and egg products, are safe, wholesome, sanitary, and properly labeled.

Food Safety and Inspection Service:

Total Diet Study (TDS)

- Ongoing FDA program that determines levels of various contaminants and nutrients in foods.
- Established in 1961 to monitor radiation in foods.
- Now monitors for pesticide residues, industrial chemicals, and toxic and nutrient elements.

Food Safety and Inspection Service:

TDS - Process

1. Purchase samples of food.

2. Prepare foods as they would be typically be consumed.

3. Analyze the foods for contaminants and nutrients.

4. Calculate dietary exposure based on average consumption amounts for each food.

Food Safety and Inspection Service:

TDS - Metals

- Monitors for: As, Cd, Calcium (Ca), Cu, Fe, Pb, Magnesium (Mg), Mn, Hg, Ni, Potassium (K), Se, Sodium (Na), Zn

- Others: Phosphorus (P), Iodine (I).

Food Safety and Inspection Service:

Results

Food Safety and Inspection Service:

FSIS – 2012 National Residue Program

Cd and Pb

Metal	Animal Class	Tissue Type	Positives	Analyses	Percent Positive
Cd	Beef Cow	Muscle	0	54	0.00%
	Bob Veal	Muscle	0	57	0.00%
	Dairy Cow	Muscle	0	62	0.00%
	Heifer	Muscle	0	40	0.00%
	Market Hogs	Kidney	70	70	100.00%
	Market Hogs	Muscle	0	130	0.00%
	Sow	Muscle	0	64	0.00%
	Steer	Muscle	0	40	0.00%
	Young Chicken	Muscle	0	52	0.00%
	Young Turkey	Muscle	0	59	0.00%
Total			70	628	11.15%
Pb	Beef Cow	Muscle	1	54	1.85%
	Bob Veal	Muscle	0	57	0.00%
	Dairy Cow	Muscle	0	62	0.00%
	Heifer	Muscle	0	40	0.00%
	Market Hogs	Kidney	4	53	7.55%
	Market Hogs	Muscle	0	88	0.00%
	Sow	Muscle	1	64	1.56%
	Steer	Muscle	0	40	0.00%
	Young Chicken	Muscle	0	52	0.00%
	Young Turkey	Muscle	0	59	0.00%
Total			6	569	1.05%

As

Metal	Animal Class	Positives	Analyses	Percent Positive
As	Market Hogs	0	67	0.00%

Food Safety and Inspection Service:

FSIS – 2012 National Residue Program Concentrations

Metal	Animal Class	Tissue Type	Concentration Range (ppb)	Median Levels (ppb)	Mean Levels (ppb)
Cd	Market Hogs	Kidney	20.74 - 424.74	99.81	137.90
Pb	Beef Cows	Muscle	33.94	N/A	N/A
	Market Hogs	Kidney	32.84 - 102.20	66.24	66.87
	Sows	Muscle	30.48	N/A	N/A

Food Safety and Inspection Service:

FDA - Total Diet Study

Metal	Number of product types metal was detected in	Total number of product types sampled	% of positive analyses
As	90	260	34.6
Cd	158	237	66.7
Pb	189	275	68.7
Mn	86	239	36.0
Mo	16	257	6.2
Se	110	251	43.8

TDS – Top Three Product Types per Metal

Metal	TDS Food Name	No. analyses	Non-detects	Detects	Mean (ppm)	Max (ppm)
Arsenic	Granola w/ raisins	24	2	21	0.019	0.061
	Granola bar, w/ raisins	24	0	20	0.035	0.058
	Chicken breast, fried, fast-food (w/ skin)	24	4	20	0.015	0.033
	Chicken leg, fried, fast-food (w/skin)	24	4	19	0.016	0.044
Cadmium	Apple pie, fresh/frozen	24	0	23	0.005	0.007
	Oatmeal, plain, cooked	24	2	22	0.002	0.004
	Popcorn, microwave, butter-flavored	24	0	22	0.006	0.012
	Pinto beans, dry, boiled	24	4	20	0.002	0.004
	BF, cereal, oatmeal, dry, prep w/water	24	4	20	0.003	0.005
	Chicken leg, fried, fast-food (w/skin)	24	2	20	0.004	0.008
	Coleslaw, mayonnaise-type, from grocery/deli	24	0	20	0.004	0.008
Lead	Syrup, chocolate	24	1	23	0.016	0.027
	Apricots	24	1	22	0.015	0.036
	Sweet potatoes, canned	24	2	22	0.012	0.018
	BF, juice, grape	24	1	21	0.011	0.02

Food Safety and Inspection Service:

TDS – Top Three Product Types per Metal

Metal	TDS Food Name	No. analyses	Non-detects	Detects	Mean (ppm)	Max (ppm)
Manganese	Peach, raw/frozen	24	0	24	0.46	0.61
	Pear, raw (w/ peel)	24	0	24	0.43	0.54
	Tomato juice, bottled	24	0	24	0.64	0.77
	Cantaloupe, raw/frozen	24	0	23	0.44	0.89
	Soup, vegetable beef, canned, cond, prep w/ water	24	0	23	0.62	0.84
	BF, pears	24	1	23	0.44	0.63
	Clam chowder, New England, canned cond, prep w/ whl milk	24	1	23	0.44	0.68
	Apricots, canned in heavy/light syrup	24	1	23	0.39	0.51
	Corn, canned	24	0	22	0.68	1.18
	Watermelon, raw/frozen	24	0	22	0.5	1
	BF, peaches	24	1	22	0.66	0.92
	Mushrooms, raw	24	2	22	0.4	0.57
	Beef and vegetable stew, canned	23	1	22	0.51	0.72

Food Safety and Inspection Service:

TDS – Top Three Product Types per Metal

Metal	TDS Food Name	No. analyses	Non-detects	Detects	Mean (ppm)	Max (ppm)
Molybdenum	Liver (beef/calf), pan-cooked w/ oil	8	0	8	1.45	1.66
	Pinto beans, dry, boiled	8	0	8	1.32	1.64
	Crisped rice cereal	8	0	8	0.898	1.28
	Oat ring cereal	8	0	8	1.26	1.44
	White beans, dry, boiled	8	0	8	1.137	1.78
	Granola w/ raisins	8	2	6	0.589	0.815
	Shredded wheat cereal	8	3	5	0.554	0.984
Selenium	Half & half cream	20	0	20	0.026	0.053
	Infant formula, milk-based, low iron, RTF	20	0	20	0.026	0.036
	Infant formula, soy-based, RTF	20	0	20	0.024	0.037
	Beef and vegetable stew, canned	20	0	20	0.024	0.036
	Corn/hominy grits, enriched, cooked	20	1	19	0.018	0.026
	BF, turkey and rice	20	0	19	0.027	0.046
	Soup, bean w/ bacon/pork, canned, cond, prep w/ water	20	0	19	0.024	0.051
	Sour cream dip, any flavor	20	0	19	0.029	0.042
	Milk, whole, fluid	20	0	18	0.032	0.044
	Milk, chocolate, lowfat, fluid	20	2	18	0.029	0.039
	Salad dressing, creamy/buttermilk type, regular	20	1	18	0.027	0.049
	Salad dressing, creamy/buttermilk type, low-calorie	20	2	18	0.018	0.033

Food Safety and Inspection Service:

Paracelsus

Dosis facit venenum.

The dose makes the poison.

- The concentrations presented here are of limited value unless an exposure assessment is performed to determine if the levels found and the rate of consumption pose a public health risk.

Food Safety and Inspection Service:

Dose and Dose-Rate matter

Food Safety and Inspection Service:

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Questions?

¿Preguntas?

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Food Safety and Inspection Service:

References/Links

- FSIS 2012 Red Book: http://www.fsis.usda.gov/wps/portal/fsis/topics/data-collection-and-reports/chemistry/red-books/red-book
- FSIS 2015 Blue Book: http://www.fsis.usda.gov/wps/portal/fsis/topics/data-collection-and-reports/chemistry/blue-books/ct_index
- Total Diet Study: http://www.fda.gov/Food/FoodScienceResearch/TotalDietStudy/default.htm

Dietary Exposure Assessment of Metals in Meat and Poultry Products Consumed in the United States Regulated by the Food Safety and Inspection Service

Abstract # 331
Poster Board # 550

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ABSTRACT

The Food Safety and Inspection Service (FSIS) is the public health agency in the U.S. Department of Agriculture responsible for ensuring that the nation's commercial supply of meat, poultry, and egg products is safe, wholesome, and correctly labeled and packaged. For many years, FSIS has monitored these products for veterinary drugs, pesticides, and environmental contaminants through the United States National Residue Program (U.S. NRP). FSIS tests for the trace elements cadmium (Cd), cobalt (Co), lead (Pb), manganese (Mn), molybdenum (Mo), selenium (Se), and thallium (Tl). Chronic exposure to excessive levels of these elements could pose a public health risk. Concentrations of each trace element were measured in muscle tissues of cattle, swine, chicken, and turkey and used to conduct chronic exposure assessments. The data (mean and maximum concentrations) were used to estimate exposures for different U.S. populations, which were compared to health-based guidance values (HBGVs) to determine if chronic consumption of contaminated product could pose a health risk to the consumer. Assuming either mean or maximum levels of Cd, Co, Mn, Mo, and Pb, population exposure from FSIS-regulated commodities is below 5% of the respective HBGV. The metal with an established HBGV that resulted in the highest exposure was Se consumed by children ages 1–5, at 58.9% of the HBGV, when the maximum concentration was used in the assessment. Based on our assessments, chronic consumption of FSIS-regulated commodities does not constitute a health risk to the public from metal intoxication. Under the U.S. NRP, FSIS will continue to conduct similar assessments to determine any potential public health risk.

INTRODUCTION

FSIS has been monitoring meat, poultry, and egg products for the presence of chemicals since 1967. Among these chemicals, the metals Pb and Cd have been monitored for the past 15 years. Additionally, FSIS has tested for Co, Mn, Mo, Se, Tl, Cd, and Pb, taken from one single muscle sample of bovine (dairy cows, beef cows, steers, and heifers), porcine (market hogs and sows), chicken, and turkey tissues since 2012. Table 1 shows the number of trace element results obtained from the U.S. NRP muscle tissue samples for calendar years 2012 and 2013 and analyzed for the dietary exposure assessments presented here.

Table 1. Positive Trace Element Results Analyzed for Dietary Exposure Assessment

	Bovine		Porcine		Chicken		Turkey	
Trace Elements	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
Cadmium	145 (198)*	170 (440)	88 (215)	164 (296)	39 (52)	58 (158)	43 (59)	59 (177)
Cobalt	145 (145)	168 (442)	88 (90)	106 (302)	39 (39)	58 (160)	43 (46)	59 (182)
Lead	145 (198)	168 (438)	99 (168)	108 (295)	39 (52)	59 (159)	43 (59)	59 (168)
Manganese	145 (145)	229 (449)	88 (90)	108 (300)	39 (39)	59 (160)	43 (46)	62 (179)
Molybdenum	145 (145)	170 (453)	88 (90)	108 (304)	39 (39)	59 (161)	43 (46)	59 (179)
Selenium	145 (145)	169 (443)	89 (90)	129 (300)	39 (39)	62 (163)	43 (46)	62 (180)
Thallium	145 (145)	168 (443)	88 (90)	106 (302)	39 (39)	58 (160)	43 (46)	59 (179)

*Number in parentheses represents the total number of chemical analyses for each trace element performed.

MATERIALS & METHODS

Quantification of Metals

The method used for detection of metals in bovine, porcine, chicken, and turkey muscle tissue has been described previously[1]. Metals were quantified using inductively coupled plasma mass spectrometry (ICP-MS) from muscle tissues digested in concentrated nitric acid (HNO_3) and extracted in diluted HNO_3. The instrument was tuned and calibrated with three calibration standards and a blank. The calculated metal concentrations must be within ±12% of their accepted value. Quantification was performed using an Agilent model 7500ce ICP-MS by the Eastern Laboratory of the FSIS in Athens.

Dietary Exposure and Evaluation Model Analyses

The means were calculated and the maximum concentrations were identified from results obtained (above and below the minimum level of applicability (MLA); Table 2). Based on those results (Table 3), we performed two dietary exposure assessments on each metal: (1) calculated mean concentrations obtained from each product type and (2) identified maximum concentrations from each product type. The Dietary Exposure and Evaluation Model (DEEM) freeware version 4.02 developed by Durango Software, LLC[2] was used to determine the exposure to each trace element that would result from daily consumption of FSIS-regulated products containing either the mean or maximum concentrations of the element. The results show the exposure levels for different population subgroups for each metal. The commodities selected in the DEEM software for the assessments were meat from beef, pork, chicken, and turkey. HBGVs (Table 4), such as the noncancer chronic oral reference dose (RfD) established by the U.S. EPA or tolerable daily intake (TDI) established by RIVM, for each trace element were used to estimate the percent of the HBGV from consumption of FSIS-regulated products.

Table 2. Minimum Level of Applicability of Each Trace Element.

Trace Elements	MLA (ppm)
Cadmium	≥ 0.01
Cobalt	≥ 0.025
Lead	≥ 0.025
Manganese	≥ 0.2
Molybdenum	≥ 0.05
Selenium	≥ 0.5
Thallium	≥ 0.05

Table 3. Trace Element Input Concentrations Used in DEEM™ (ppm)

	Bovine		Porcine		Chicken		Turkey	
Trace Elements	**Average**	**Maximum**	**Average**	**Maximum**	**Average**	**Maximum**	**Average**	**Maximum**
Cadmium	0.000769	0.04923	0.001125	0.00682	0.000238	0.00148	0.000668	0.00327
Cobalt	0.002581	0.0269	0.000324	0.00303	0.000359	0.00311	0.000754	0.0092
Lead	0.00106	0.03394	0.001574	0.09664	0.000931	0.04349	0.000507	0.00703
Manganese	0.153307	0.28967	0.07331	0.25086	0.10344	0.22554	0.13173	0.28435
Molybdenum	0.01165	0.05265	0.00941	0.06307	0.029959	0.05831	0.02158	0.03852
Selenium	0.22175	1.3768	0.35907	0.77231	0.28294	0.72127	0.28523	0.60415
Thallium	0.000197	0.00373	0.000284	0.01288	0.001339	0.00349	0.000186	0.0026

Table 4. Health-Based Guideline Values used in DEEM™ to estimate % of noncancerous oral reference dose from exposure to each trace element via consumption of FSIS-regulated products.

Trace Elements	Health-Based Guideline Value (mg/kg BW/day)
Cadmium	0.001*
Cobalt	0.0014#
Lead	0.00357#
Manganese	0.14*
Molybdenum	0.005*
Selenium	0.005*
Thallium	0.000003^

*Noncancer oral reference dose (oRfD) set by the US EPA.
#Noncancer oral tolerable daily intake (TDI) set by RIVM.
^Noncancer oRfD derived, but not established.

RESULTS

Cadmium

Cadmium Average Exposure Assessment Oral Chronic Reference Dose 0.001 mg/kg bw/day Total Exposure by Population Subgroup		
	Total Exposure	
Population Subgroup	**mg/kg bw/day**	**% of RfD**
Total US Population	0.000001	0.1%
All Infants	0.000000	0.0%
Children 1-2	0.000002	0.2%
Children 3-5	0.000002	0.2%
Children 6-12	0.000001	0.1%
Youth 13-19	0.000001	0.1%
Adults 20-49	0.000001	0.1%
Adults 50-99	0.000001	0.1%
Female 13-49	0.000001	0.1%

Cadmium Maximum Exposure Assessment Oral Chronic Reference Dose = 0.001 mg/kg 0.001 mg/kg bw/day Total Exposure by Population Subgroup		
	Total Exposure	
Population Subgroup	**mg/kg bw/day**	**% of RfD**
Total US Population	0.000032	3.2%
All Infants	0.000010	1.0%
Children 1-2	0.000056	5.6%
Children 3-5	0.000057	5.7%
Children 6-12	0.000046	4.6%
Youth 13-19	0.000032	3.2%
Adults 20-49	0.000030	3.0%
Adults 50-99	0.000024	2.4%
Female 13-49	0.000024	2.4%

Cobalt

Cobalt Average Exposure Assessment Oral Chronic Tolerable Daily Intake 0.0014 mg/kg bw/day Total Exposure by Population Subgroup		
	Total Exposure	
Population Subgroup	**mg/kg bw/day**	**% of TDI**
Total US Population	0.000002	0.1%
All Infants	0.000001	0.0%
Children 1-2	0.000003	0.2%
Children 3-5	0.000003	0.2%
Children 6-12	0.000003	0.2%
Youth 13-19	0.000002	0.1%
Adults 20-49	0.000002	0.1%
Adults 50-99	0.000001	0.1%
Female 13-49	0.000001	0.1%

Cobalt Maximum Exposure Assessment Oral Chronic Tolerable Daily Intake 0.0014 mg/kg bw/day Total Exposure by Population Subgroup		
	Total Exposure	
Population Subgroup	**mg/kg bw/day**	**% of TDI**
Total US Population	0.000019	1.4%
All Infants	0.000006	0.5%
Children 1-2	0.000035	2.5%
Children 3-5	0.000036	2.5%
Children 6-12	0.000028	2.0%
Youth 13-19	0.00002	1.4%
Adults 20-49	0.000018	1.3%
Adults 50-99	0.000015	1.1%
Female 13-49	0.000015	1.1%

Lead

Lead Average Exposure Assessment Oral Chronic Tolerable Daily Intake 0.00357 mg/kg bw/day Total Exposure by Population Subgroup		
	Total Exposure	
Population Subgroup	**mg/kg bw/day**	**% of TDI**
Total US Population	0.000002	0.0%
All Infants	0.000001	0.0%
Children 1-2	0.000003	0.1%
Children 3-5	0.000003	0.1%
Children 6-12	0.000002	0.1%
Youth 13-19	0.000002	0.0%
Adults 20-49	0.000002	0.0%
Adults 50-99	0.000001	0.0%
Female 13-49	0.000001	0.0%

Lead Maximum Exposure Assessment Oral Chronic Tolerable Daily Intake 0.00357 mg/kg bw/day Total Exposure by Population Subgroup		
	Total Exposure	
Population Subgroup	**mg/kg bw/day**	**% of TDI**
Total US Population	0.000072	2.0%
All Infants	0.000025	0.7%
Children 1-2	0.000145	4.1%
Children 3-5	0.000147	4.1%
Children 6-12	0.000103	2.9%
Youth 13-19	0.000073	2.0%
Adults 20-49	0.00067	1.9%
Adults 50-99	0.000055	1.6%
Female 13-49	0.000056	1.6%

Manganese

Manganese Average Exposure Assessment Oral Chronic Reference Dose 0.14 mg/kg bw/day Total Exposure by Population Subgroup		
	Total Exposure	
Population Subgroup	**mg/kg bw/day**	**% of RfD**
Total US Population	0.000183	0.1%
All Infants	0.000066	0.0%
Children 1-2	0.000371	0.3%
Children 3-5	0.000367	0.3%
Children 6-12	0.000265	0.2%
Youth 13-19	0.000188	0.1%
Adults 20-49	0.000171	0.1%
Adults 50-99	0.000136	0.1%
Female 13-49	0.000146	0.1%

Manganese Maximum Exposure Assessment Oral Chronic Reference Dose 0.14 mg/kg bw/day Total Exposure by Population Subgroup		
	Total Exposure	
Population Subgroup	**mg/kg bw/day**	**% of RfD**
Total US Population	0.000398	0.3%
All Infants	0.000142	0.1%
Children 1-2	0.000808	0.6%
Children 3-5	0.000803	0.6%
Children 6-12	0.000575	0.4%
Youth 13-19	0.000408	0.3%
Adults 20-49	0.000372	0.3%
Adults 50-99	0.000299	0.2%
Female 13-49	0.000316	0.2%

Molybdenum

Molybdenum Average Exposure Assessment Oral Chronic Reference Dose 0.005 mg/kg bw/day Total Exposure by Population Subgroup		
	Total Exposure	
Population Subgroup	**mg/kg bw/day**	**% of RfD**
Total US Population	0.000029	0.6%
All Infants	0.000011	0.2%
Children 1-2	0.000064	1.3%
Children 3-5	0.000063	1.3%
Children 6-12	0.000042	0.8%
Youth 13-19	0.00003	0.6%
Adults 20-49	0.000026	0.5%
Adults 50-99	0.0000021	0.4%
Female 13-49	0.000024	0.5%

Molybdenum Maximum Exposure Assessment Oral Chronic Reference Dose 0.005 mg/kg bw/day Total Exposure by Population Subgroup		
	Total Exposure	
Population Subgroup	**mg/kg bw/day**	**% of RfD**
Total US Population	0.000085	1.7%
All Infants	0.000031	0.6%
Children 1-2	0.000176	3.5%
Children 3-5	0.000176	3.5%
Children 6-12	0.000123	2.5%
Youth 13-19	0.000088	1.8%
Adults 20-49	0.00008	1.6%
Adults 50-99	0.000064	1.3%
Female 13-49	0.000068	1.4%

Selenium

Selenium Average Exposure Assessment Oral Chronic Reference Dose 0.005 mg/kg bw/day Total Exposure by Population Subgroup		
	Total Exposure	
Population Subgroup	**mg/kg bw/day**	**% of RfD**
Total US Population	0.000422	8.4%
All Infants	0.000152	3.0%
Children 1-2	0.000874	17.5%
Children 3-5	0.000869	17.4%
Children 6-12	0.000607	12.1%
Youth 13-19	0.000431	8.6%
Adults 20-49	0.000392	7.8%
Adults 50-99	0.000317	6.3%
Female 13-49	0.000335	6.7%

Selenium Maximum Exposure Assessment Oral Chronic Reference Dose 0.005 mg/kg bw/day Total Exposure by Population Subgroup		
	Total Exposure	
Population Subgroup	**mg/kg bw/day**	**% of RfD**
Total US Population	0.00149	29.8%
All Infants	0.000522	10.4%
Children 1-2	0.002945	58.9%
Children 3-5	0.002943	58.9%
Children 6-12	0.002157	43.1%
Youth 13-19	0.001528	30.6%
Adults 20-49	0.001398	28.0%
Adults 50-99	0.001124	22.5%
Female 13-49	0.001169	23.4%

Thallium

Thallium Average Exposure Assessment Oral Chronic Reference Dose None (Old 0.000003 mg/kg bw/day) Total Exposure by Population Subgroup		
	Total Exposure	
Population Subgroup	**mg/kg bw/day**	**% of RfD**
Total US Population	0.000001	32.2%
All Infants	0.000000	0.0%
Children 1-2	0.000002	76.0%
Children 3-5	0.000002	73.6%
Children 6-12	0.000001	47.5%
Youth 13-19	0.000001	34.3%
Adults 20-49	0.000001	29.3%
Adults 50-99	0.000001	22.3%
Female 13-49	0.000001	26.9%

Thallium Maximum Exposure Assessment Oral Chronic Reference Dose None (Old 0.000003 mg/kg bw/day) Total Exposure by Population Subgroup		
	Total Exposure	
Population Subgroup	**mg/kg bw/day**	**% of RfD**
Total US Population	0.000008	267.2%
All Infants	0.000003	88.4%
Children 1-2	0.000016	520.1%
Children 3-5	0.000016	533.1%
Children 6-12	0.000011	377.2%
Youth 13-19	0.000008	267.2%
Adults 20-49	0.000007	249.1%
Adults 50-99	0.000006	209.5%
Female 13-49	0.000006	202.8%

DISCUSSION & FUTURE WORK

According to our assessment, no adverse health effects are expected from chronic exposure to the trace elements, Cd, Co, Pb, Mn, Mo, or Se, via dietary consumption of FSIS-regulated products. Exposure to Se from FSIS-regulated products represented the highest of all of the trace elements assessed that have an established HBGV. At the same time, exposure to Tl was higher than Se when comparing the mean and maximum concentrations found in the muscle tissues of the commodities FSIS regulates. However, since a HBGV has not been established for Tl at this time we cannot determine whether exposure to the metal through consumption of FSIS-regulated product could lead to an adverse health outcome. Children represented the population with the highest percent of RfD, due to the body weight to consumption rate ratio. In general, children might represent the population subgroup with the highest risk of developing health effects from exposure to trace elements.

Similar assessments will be performed by analyzing mixtures of chemicals harbored in a single product type including levels of trace elements harbored in other food groups that could lead to adverse health effects to consumers. Additionally, FSIS may correlate this data with information from biomonitoring databases such as NHANES to further characterize exposure to the metals through dietary consumption.

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