RESIDUES AND TRACE ELEMENTS

Element and Radionuclide Concentrations in Food: FDA Total Diet Study 1991–1996

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Foods purchased throughout the United States during 1991–1997 under the U.S. Food and Drug Administration's Total Diet Study (TDS) program were analyzed for elements and radionuclides. The program is described with emphasis on food analysis and quality control, including independent interlaboratory exercises. Analytical results are summarized for Cd, Pb, Ni, As, Hg, Se, Cu, Zn, Mn, Fe, Mg, Ca, P, K, and Na and for ^{137}Cs, ^{131}I, ^{106}Ru, and ^{90}Sr. Concentration data are provided to expand the information base used to support assessments of the safety and nutritive value of the U.S. food supply and for their potential use in food composition databases. For selected foods, comparisons were made with past TDS results and with those reported in the literature. An extensive listing of the analytical data is available on the FDA CFSAN Website.

The U.S. Food and Drug Administration's (FDA) Total Diet Study (TDS) program has been used to monitor selected chemical contaminants in the U.S. food supply since 1961 (1, 2). The TDS initially monitored radionuclides and pesticide residues, but was expanded in the 1970s to include toxic and nutrient elements. The study identifies trends and isolated contamination sources, and serves as a measure of the effectiveness of pertinent U.S. regulations and initiatives.

The several hundred foods in the TDS are selected from food consumption surveys that contain data on thousands of foods consumed in the United States. A "market basket" of these TDS foods is collected from a specified region of the country, prepared for consumption, and analyzed. The last major dietary revision to the TDS occurred in 1991 (3–5) when foods were selected from the 1987–88 U.S. Department of Agriculture's Nationwide Food Consumption Survey. The revision changed the number of TDS foods analyzed in a market basket (MB) since 1982 from 234 (representing 8 age–sex groups; 2) to 265 (representing 14 age–sex groups; 2). The 1991-revised MB consisted of 182 foods from the previous MB and 83 new foods. This study reports element and radionuclide concentrations in the TDS foods from 1991 when the revision began.

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TDS foods were analyzed for Cd, Pb, Ni, As, Hg, Se, Cu, Zn, Mn, Fe, Mg, Ca, P, K, Na, ^{137}Cs, ^{131}I, ^{106}Ru, ^{90}Sr, and ^{40}K. Analysis of TDS foods for Ni was added to the TDS beginning in summer 1996. FDA is providing TDS element and radionuclide concentration data to document the data used to support assessments of the safety and nutritive value of the U.S. food supply and for their potential use in food composition databases. Intakes of these analytes based on the TDS food consumption figures will be reported in the future.

Experimental

Sampling

TDS foods were collected ca 4 times per year, once from each of 4 geographic regions of the United States (east, central, west, and south) from September 1991 to November 1996. Eighteen MBs were collected during this period. An MB consisted of ca 260 foods collected from each of 3 cities (represented by a standard metropolitan statistical area) within the geographical region. Timely processing without spoilage was ensured by collection of an MB over 4 weeks. The foods were purchased from grocery stores and fast-food restaurants and sent to FDA's Kansas City District Laboratory (KCDL) in Lenexa, KS. Table 1 identifies the MB, collection start dates, and collection locations. Foods that required washing, trimming, peeling, or cooking were sent to an institutional kitchen (Belton Methodist Church, Belton, MO) for preparation according to specified instructions and recipes (5). Equal portions of the food collected from each city were used in the recipe to prepare the TDS foods. KCDL provided recipe ingredients (e.g., spices and condiments) from local sources to the institutional kitchen. Rinsing and cooking water were deionized and the foods were prepared with stainless steel cookware and utensils. The edible portion of table-ready foods from each of the 3 cities was combined in equal weight portions and homogenized to produce a composite representing each TDS food. The edible portion of the food prepared from a recipe was also homogenized. TDS foods were stored frozen until analyzed. Each TDS food was identified with a unique number to aid in tracking, discussion, and database searching.

The 1991 revision of the TDS MB specified collection of 265 TDS foods; however, an MB always had fewer foods be-

cause of product non-availability. One food (infant vegetables and liver) was never available for collection. The following 3 infant foods were not available after MB 92-1: vegetables and chicken or turkey (TDS food 208), vegetables and beef (TDS food 209), and vegetables and ham (TDS food 210). The infant food egg yolk (TDS food 310) was not available after MB 95-2. The infant food beets (TDS food 314) was not available after MB 96-2 and was replaced with infant food squash (TDS food 320) in 1998 (i.e., MB 98-2). Infant food squash had been part of a separate baby food study conducted in conjunction with the TDS since MB 91-3 and included the determination of Cd, Pb, and Ni. These results for infant food squash are also reported for comparison with future TDS infant food squash results. Foods that were unavailable at the time of an MB's collection because of the growing season (e.g., strawberries and cherries) were either not collected or collected during the next available season. Occasionally, foods that were unavailable in the assigned collection location were collected locally by FDA's KCDL.

Element Analyses

Beginning with MB 91-3, element analytical methods were the same as those used for the TDS for many years (6). Starting with MB 94-1, many of the laboratory analytical operations were documented in standard operating procedures, including analytical methods, contamination control (7), and quality assurance (8). Over the course of the study, some minor changes to the methods were implemented to improve analytical quality (i.e., changes to ash aid and matrix modifiers) and some instruments were replaced. Beginning with MB 94-1, new equipment used to determine As and Se provided lower detection limits. Beginning with MB 95-3, new automated equipment raised detection limits slightly for Hg but still provided acceptable monitoring capabilities. All changes to the methods or equipment were documented in revised standard operating procedures.

Each TDS food was analyzed for all elements except Hg. Cd, Ni, and Pb were determined by dry ash mineralization (9) with quantitation by graphite furnace atomic absorption spectrometry (AAS; 10). Ni determination began with MB 96-3. A test solution prepared by a nitric/perchloric/sulfuric acid mineralization (11) was used for 2 determinative procedures: inductively coupled plasma–atomic emission spectrometry (ICP–AES; 12) for Na, K, P, Ca, Mg, Mn, Fe, Cu, and Zn; and hydride generation atomic AAS (13, 14) for As (total) and Se. Hg (total) was determined by nitric/sulfuric acid mineralization (15) with quantitation by cold vapor AAS (16). Only 47 TDS foods were analyzed for Hg, and these foods were selected for their importance to certain populations or past Hg results.

Limits of detection (LODs) and limits of quantitation (LOQs) were defined to be 3 and 10 times, respectively, the standard deviation (SD) of replicate measurements of independent control blanks (17). These limits depended in part on the amount of food analyzed and the dilution amounts specified by the method. Table 2 shows nominal limits for each element based on a 5 g test portion. The mass of a test portion var-

Table 1. FDA Total Diet Study market baskets

Market basket No.[a]	Collection start date[b]	Collection locations
91-3	September 1991	Philadelphia, PA; Camden, NJ; Buffalo, NY
92-1	January 1992	Riverside/San Bernardino/Ontario, CA; Santa Clara, CA; Salem, OR
92-2	July 1992	Mobile, AL; Shreveport, LA; Charleston, WV
93-1	October 1992	Chicago, IL; Cincinnati, OH; Kalamazoo/Portage, MI
93-2	March 1993	New York, NY; Boston, MA; New Brunswick/Perth Amboy/Sayreville, NJ
93-3	June 1993	Colorado Springs, CO; Sacramento, CA; Spokane, WA
94-1	October 1993	San Antonio, TX; Raleigh, NC; San Juan, PR
94-2	January 1994	Rockford, IL; Omaha, NE; Fargo, ND; Moorhead, MN
94-3	May 1994	Albany/Schenectady/Troy, NY; Nassau/Suffolk, NY; Pittsburgh, PA
94-4	August 1994	Albuquerque, NM; San Diego, CA; Seattle, WA
95-1	October 1994	Baltimore, MD; Roanoke, VA; Orlando, FL
95-2	February 1995	Brownsville, TX; San Diego, CA; Tucson, AZ
95-3	June 1995	Hartford, CT; Rochester, NY; Monmouth/Ocean, NJ
96-1	October 1995	Salt Lake City/Ogden, UT; Bakersfield, CA; Tacoma, WA
96-2	January 1996	Charleston, SC; Lafayette, LA; West Palm Beach/Boca Raton/Delray Beach, FL
96-3	April 1996	Portland, ME; New York/Westchester County, NY; Scranton/Wilkes-Barre, PA
96-4	August 1996	Davenport, IA; Rock Island/Moline, IL; Lansing/East Lansing, MI; St. Cloud, MN
97-1	November 1996	Phoenix, AZ; Fresno, CA; San Antonio, TX

[a] First number is the U.S. government's fiscal year (October–September) and the second number is the sequence collected within the fiscal year.
[b] Collection over four 1-week periods.

Table 2. Nominal analytical limits for FDA's Total Diet Study[a]

Element	Limit of detection, mg/kg	Limit of quantitation, mg/kg
As[b]	0.04	0.12
As[c]	0.01	0.03
Ca	3	10
Cd	0.002	0.005
Cu	0.2	0.7
Fe	0.5	2
Hg[d]	0.006	0.02
Hg[e]	0.01	0.04
K	6	20
Mg	3	8
Mn	0.2	1
Na	5	20
Ni	0.025	0.09
P	8	30
Pb	0.008	0.03
Se[b]	0.04	0.12
Se[c]	0.01	0.03
Zn	0.2	1

[a] Based on 5 g test portion.
[b] Market baskets 91-3 through 93-3.
[c] Market baskets 94-1 through 97-1.
[d] Market baskets 91-3 through 95-2.
[e] Market baskets 95-3 through 97-1.

ied from 1 to 10 g and was usually restricted by the food's reactivity during mineralization. Concentrations between LOD and LOQ were designated 'trace' concentrations.

Radionuclide Analyses

Radionuclides were determined in the first MB collected in a fiscal year. Portions of the MB were shipped to FDA's Winchester Engineering and Analytical Center in Winchester, MA.

Gamma-ray spectrometry with no food matrix alteration was used to determine ^{137}Cs, ^{131}I, ^{106}Ru, and ^{40}K (18, 19). Beta spectrometry with food digestion and radiochemical separation was used to determine ^{90}Sr (20). The radionuclide techniques varied only slightly between MBs. The most significant change was in instrumentation used to determine gamma-ray emitting radionuclides. Gamma-ray detectors had NaI(Tl) crystals for the analysis of MB 92-1. Starting with MB 93-1, gamma-ray detectors having Ge crystals were used to provide improved energy resolution.

Concentrations of the natural radionuclide ^{40}K were determined for quality control purposes and for comparison with contaminant radionuclides. The ^{40}K concentration, in Bq/kg units, was converted to K concentration, in mg/kg, using the conversion factor 31.7 mg K per Bq (derived from the decay constant of ^{40}K and its natural abundance).

For gamma-ray emitting radionuclides, LODs were defined to be 3 times the SD of the spectral baseline (Compton scattering continuum). Limits depended in part on the amount of food analyzed. For gamma-ray emitting radionuclides, a fixed volume of test portion, ca 400 mL, was analyzed without modification of the matrix. Therefore, the test portion's mass varied according to the density of the food. For ^{90}Sr, the LOD was defined as 3 times the SD of replicate measurements of independent control blanks. For ^{90}Sr determination, the mass of food was ca 500 g. As the food was digested, counting geometries were uniform regardless of the food density and volume. LODs (Bq/kg) were ^{137}Cs, 2; ^{131}I, 3; ^{106}Ru, 15; and ^{90}Sr, 0.1. For K, the LOD was ca 2000 mg/kg. LOQs were not defined for radionuclides.

Quality Control—Elements

Quality control activities included checks to ensure proper operation of laboratory equipment, analysis of blanks to verify lack of contamination, analysis of test materials to demonstrate precision and accuracy, and interlaboratory exercises to verify accuracy. Test portions were analyzed in batches and a relatively large number of quality control samples were included with each batch. Quality control samples included reference materials, fortified test portions, control blanks, and replicate test portions. Acceptance criteria were established for the results of each of these quality control measures. When acceptance criteria were not met for a batch, the results were discarded and a replacement batch was prepared and analyzed. Included with ca 62 000 element results for TDS foods were ca 4500 results for reference materials, 1700 results for test portion fortifications, 6800 results for control blanks, and 3600 results for replicate test portions.

Fortifications, reference materials, and replicates were analyzed to obtain information on accuracy and precision (Table 3). The mean percent recovery, relative SD, and number of results are included for each element for both fortifications and reference materials. Accuracy and precision were acceptable. As expected, the highest relative SDs for reference material analysis were for elements determined by methods having the largest components of uncertainty arising from random effects, e.g., As, Cd, Hg, Ni, Pb, and Se. The replicate analysis scheme was designed not to measure precision but to confirm whether original results were reproducible. Relative standard deviations (RSDs) were examined for the cases with 3 or more replicate TDS food results. For replicate results above the LOQ, the vast majority were < 7% RSD, indicating excellent replicate precision.

Results were compared with previous TDS MB results as a quality control procedure. A result that was significantly different from past values prompted a reanalysis of the TDS food (2 replicates). An exception was made for significantly high results if a food's packaging label indicated that the food was fortified with the element. The reanalysis results either verified the original result or, if different, replaced the original result.

Table 3. Summary of fortification and reference material recovery results for FDA's Total Diet Study[a]

	Fortification			Reference materials		
Element	*n*	Mean	SD	*n*	Mean	SD
Cadmium	311	88.5	9.29	555	93.8	7.43
Lead	281	85.5	10.05	257	84.6	11.27
Nickel	24	96.3	11.40	155	90.1	9.06
Arsenic	180	99.1	10.79	336	101.1	10.44
Mercury	30	99.9	4.95	70	95.7	17.05
Selenium	164	97.7	14.77	318	90.6	12.78
Copper	75	95.3	7.44	286	96.4	7.67
Zinc	73	101.9	8.29	283	99.0	6.46
Manganese	70	96.2	8.51	286	97.0	7.73
Iron	73	96.9	8.05	286	93.6	9.79
Magnesium	67	98.8	8.19	236	95.3	7.24
Calcium	67	91.1	10.68	286	97.7	7.85
Phosphorus	67	94.4	8.42	237	93.2	10.68
Potassium	67	98.9	12.70	287	95.7	5.90
Sodium	67	96.0	10.83	172	93.9	6.62
Overall	1616	93.6	11.56	4050	94.7	9.84

[a] Analyses with fortifications and true values greater than or equal to the limit of quantitation.

Quality Control—Radionuclides

Quality control included periodic verification of critical measurement parameters, measurements of radiation background and control blanks, and participation in the U.S. Environmental Protection Agency's (EPA) round-robin quality assurance program. Radiation background in the laboratory was monitored for spectral interferences, including interference from radon gas. Spectral interference from radon was poorly resolved when NaI crystal gamma-ray detectors were used (i.e., MB 92-1). Spectra from these detectors were inspected manually to verify that radon interference was not being detected as a false positive for contaminant radionuclides. Beginning with MB 93-1, manual inspection was no longer necessary because Ge crystal gamma-ray detectors were used and the peaks were fully resolved. The laboratory radiation background was still monitored, however, to measure ^{40}K and other background radiation. Control blanks were analyzed for ^{90}Sr, as naturally present radionuclides in the reagents contributed to the measured signal. The EPA round-robin quality assurance program was designed to certify laboratories performing analyses for Nuclear Regulatory Commission (NRC)-licensed nuclear power plants. The results of analysis for the EPA program were acceptable.

Interlaboratory Quality Assurance—Elements

Fifteen TDS foods were selected for every MB beginning with 94-1 (12 MBs) and independently analyzed at FDA's Center for Food Safety and Applied Nutrition (CFSAN) in Washington, DC. Each set of TDS foods was analyzed by instrumental neutron activation analysis (INAA) for Ca, Cu, Fe, Mg, Mn, K, Se, Na, and Zn. (Later MBs were also analyzed for As and Cd.) Briefly, test portions of food were analyzed by using comparative INAA gamma-ray spectrometry (21). Irradiation-count conditions were 30 s irradiation at a neutron-fluence rate of $10^{18}/m^2 \cdot s$ followed immediately by 300 and 600 s counts and then by a 6 h irradiation with a 4 h count at 1 week decay and an 8 h count at 1 month decay. Test portions were contained in polyethylene bags (ca 76 μm wall thickness). Transferring the test portions after irradiation to new (nonradioactive) containers for counting eliminated the need for control blanks.

The results of these independent analyses were compared with the TDS results and evaluated by using uncertainties. For all CFSAN results, estimates of the analytical uncertainties (ca 95% relative probability level) were based on analytical data. For TDS results, uncertainties were assumed to be 60% for concentrations near LODs. For concentrations ≥ 5 LOD, uncertainties were assumed to be 30% for As, Cd, and Se, and 20% for all other elements. Results were considered to agree if uncertainties overlapped.

INAA provided ca 1800 element concentration results for ca 180 test portions from the 12 MBs. The vast majority of TDS results were verified to be accurate. The few disagreements found were expected because of nonhomogeneity in many food matrixes. Results from 6 MBs were either in full agreement or included only 1 or 2 results that were in dis-

agreement. The first MB (94-1), which had the most disagreements, was analyzed when the TDS quality assurance program was being enhanced, and the effects of these improvements would not have been fully realized. Only 5–10 results were in disagreement for each of the other 5 MBs.

The element results were also examined for patterns of disagreement and to identify likely sources of error. Some data entry mistakes were discovered and corrected. Some disagreements were obviously the result of differences in moisture content among the various test portions analyzed. For those with no obvious explanation, nonhomogeneity or isolated analytical problems were suggested. When an analytical problem was considered a possibility, the food was identified as a candidate for reexamination in future MB independent analysis to monitor for recurring matrix problems that need additional investigation.

Interlaboratory Quality Assurance—Radionuclides

The same 15 foods selected for element analysis for quality assurance were independently analyzed for radionuclides at CFSAN. The foods from only the first MB collected each fiscal year were analyzed (i.e., 4 TDS MBs were analyzed for radionuclides). Low-level gamma-ray counting (22) was used to determine gamma-ray emitting radionuclides (^{137}Cs, ^{131}I, ^{106}Ru, and ^{40}K).

These results for ca 60 test portions from the 4 MBs were compared with the TDS results and were confirmed by CFSAN results. All contaminant radionuclides were below the TDS LODs, and the natural radionuclide ^{40}K was above detection for some foods and below detection for the others.

Because contaminant radionuclides were below detection, definitive confirmation of accuracy was possible only for ^{40}K results (converted to total K). The design of the quality assurance exercises provided 4 independent sets of results: TDS gamma-ray counting, CFSAN gamma-ray counting, TDS ICP–AES, and CFSAN INAA.

Results for K generated with TDS gamma-ray counting were comparable to those from other analytical techniques for 1994, 1995, and 1997. For 1996, TDS radionuclide analysis did not produce quantitative K results. Comparison of K results from TDS gamma-ray counting (all foods) with TDS ICP–AES results (1994, 1995, and 1997) indicated that gamma-ray counting results were satisfactory.

Results

Elements

Table 4 summarizes element results for each TDS food analyzed in the 18 MBs. The mean concentration was calculated by using 0 for concentrations below the LOD. A limit of quantitation is given in Table 4 for a food if the element's mean concentration was below this limit, indicating that at least one test portion had a concentration of the element above the LOD. Replicate results were not included in the calculation of mean concentration. Supplemental information, available on FDA's Internet site (23), includes a database file of all analytical results and a document containing summary tables of analytical results for each element in each TDS food. The summary tables provide the following element information for each TDS food: TDS food description; TDS food number; number of results; number of "not detected" results; number of "trace" results; mean; SD; minimum; maximum; median; nominal LOD; and nominal LOQ.

Mean and median Cd concentrations in all TDS foods were 0.010 and 0.004 mg/kg, respectively. Cd was not detectable in about 40% of TDS foods and was at trace levels for another 13%. The individual TDS food with the highest Cd concentration was iceberg lettuce (0.323 mg/kg in MB 96-3). The 5 TDS foods with the highest mean Cd concentrations were spinach (0.125 mg/kg), infant food creamed spinach (0.090 mg/kg), beef liver (0.077 mg/kg), iceberg lettuce (0.066 mg/kg), and potato chips (0.062 mg/kg). Quantifiable concentrations of Cd were consistently present in these foods. These results are similar to mean Cd concentrations from the previous 37 TDS MBs collected between 1982 and 1991 with one exception: a lower concentration of Cd was present in potato chips from the current set of MBs (MBs 1991–1996). The mean Cd concentrations of these TDS foods from MBs 1982–1991 were spinach (0.159 mg/kg), infant food creamed spinach (0.060 mg/kg), beef liver (0.100 mg/kg), iceberg lettuce (0.044 mg/kg), and potato chips (0.149 mg/kg).

Mean and median Pb concentrations in all TDS foods were 0.005 and 0 mg/kg, respectively. Pb was not detectable in about 74% of TDS foods and was at trace levels for another 23%. The individual TDS food with the highest Pb concentration was shrimp (0.210 mg/kg in MB 93-2). The 5 TDS foods with the highest mean Pb concentrations were shrimp and sweet cucumber pickles (both 0.036 mg/kg), canned peaches (0.032 mg/kg), and beef liver and canned fruit cocktail (both 0.031 mg/kg). Trace concentrations of Pb were consistently present in these foods. These results were similar to mean Pb concentrations from MBs 1982–1991 with one exception: lower concentrations of Pb were found in both canned foods from MBs 1991–1996. The mean Pb concentrations of these TDS foods from MBs 1982–1991 were shrimp (0.030 mg/kg), canned peaches (0.123 mg/kg), beef liver (0.050 mg/kg), and canned fruit cocktail (0.134 mg/kg). Sweet cucumber pickles were not included in MBs 1982–1991. The lower Pb concentrations in the canned foods in MBs 1991–1996 can be attributed to the reduction and ultimate ban in 1995 (24) on the use of lead-soldered food cans in the United States.

Mean and median Ni concentrations in all TDS foods were 0.136 and 0.057 mg/kg, respectively. Ni was not detectable in about 33% of TDS foods and was at trace levels for another 37%. The individual TDS food with the highest Ni concentration was mixed nuts (3.66 mg/kg in MB 96-3). The 5 TDS foods with the highest mean Ni concentrations were mixed nuts (3.04 mg/kg), oat ring cereal (2.32 mg/kg), chocolate syrup (1.04 mg/kg), granola cereal (1.01 mg/kg), and peanuts (0.956 mg/kg). Quantifiable concentrations of Ni were consistently present in these foods. Relatively high levels of Ni were not observed in TDS meat products cooked in stainless steel, which differs from other investigator results (25). Ni was not routinely determined in MBs 1982–1991, but Ni concentra-

Table 4. Mean element concentrations for FDA's Total Diet Study market baskets 91-3 through 97-1[a]

TDS food name[b] (No.)	Mean concentration, mg/kg														
	Cd	Pb	Ni[c]	As	Hg[d]	Se	Cu	Zn	Mn	Fe	Mg	Ca	P	K	Na
Milk and cheese															
Whole milk, fluid (1)	nd	<0.03	nd	nd	nd	<0.04	nd	3.6	nd	<3	100	958	805	1400	369
Lowfat (2% fat) milk, fluid (2)	nd	<0.03	nd	nd	nd	<0.04	nd	4.0	nd	nd	111	1060	892	1530	404
Skim milk, fluid (4)	<0.004	<0.02	nd	<0.04	na	<0.04	nd	3.8	nd	<3	114	1090	901	1550	412
Chocolate milk, fluid (3)	<0.005	<0.03	<0.09	nd	na	<0.04	<0.9	4.0	<1	<3	140	957	843	1570	660
Evaporated milk, canned (8)	nd	<0.03	nd	<0.04	na	<0.04	nd	7.3	nd	<3	211	2070	1750	3030	861
Plain yogurt, lowfat (6)	<0.005	<0.03	nd	nd	na	<0.04	<0.9	5.6	nd	<3	157	1550	1230	2140	597
Yogurt, lowfat, fruit (235)	<0.005	<0.03	<0.09	<0.04	na	<0.04	nd	4.4	<1	<3	130	1120	965	1740	517
Cheddar cheese (12)	nd	<0.05	nd	nd	na	0.193	<1.2	35.5	<2	<3	284	6880	4580	747	5890
Swiss cheese (236)	<0.007	<0.04	nd	<0.05	na	0.182	<1.2	43.6	<2	<3	378	7920	5670	772	1920
American cheese (10)	<0.010	nd	nd	nd	na	0.183	<1.2	28.0	<2	<3	270	5510	5480	1710	14600
Cottage cheese, 4% (11)	<0.005	<0.03	<0.09	nd	na	0.073	nd	3.8	nd	<3	81	719	1420	970	3410
Cream cheese (237)	nd	<0.04	nd	<0.05	na	<0.05	nd	5.1	nd	<3	79	720	934	1100	2970
Eggs															
Eggs, boiled (37)	nd	<0.03	nd	<0.04	nd	0.282	<0.9	13.2	<1	18.5	121	618	2010	1220	1230
Eggs, fried (36)	nd	<0.03	nd	<0.04	nd	0.279	<0.9	12.9	<1	18.0	123	545	1980	1320	1330
Eggs, scrambled (35)	<0.005	<0.03	<0.09	<0.04	nd	0.209	<0.9	10.9	<1	14.6	119	617	1720	1350	2330
Meat, poultry, and fish															
Beef steak, pan-cooked (16)	<0.007	<0.04	nd	<0.04	na	0.266	1.0	56.1	nd	26.2	269	99	2280	3720	615
Beef chuck roast, baked (14)	<0.007	<0.04	nd	<0.04	na	0.237	1.0	79.6	<1	27.7	241	93	2050	3380	676
Ground beef, pan-cooked (13)	<0.007	<0.04	nd	<0.04	na	0.199	<0.9	59.4	nd	25.5	227	149	1970	3310	764
Pork chop, pan-cooked (18)	nd	<0.04	<0.12	nd	na	0.453	<0.9	28.3	<1	10.2	315	693	2770	4200	745
Ham, baked (17)	<0.010	<0.05	nd	<0.04	na	0.290	<0.9	22.0	nd	8.3	195	63	2510	2860	11400
Pork roast, baked (21)	<0.007	<0.04	nd	nd	na	0.323	<1.2	29.6	nd	9.8	227	106	2070	3250	743
Lamb chop, pan-cooked (22)	<0.007	<0.04	<0.12	nd	na	0.258	1.4	53.9	nd	22.5	281	366	2310	3590	898
Veal cutlet, pan-cooked (238)	<0.007	<0.04	<0.12	<0.04	na	0.172	0.9	39.4	nd	9.8	340	98	3010	4890	765
Pork bacon, pan-cooked (20)	<0.010	<0.05	<0.17	nd	na	0.352	1.2	27.1	nd	9.8	235	105	3540	3940	19500
Pork sausage, pan-cooked (19)	<0.010	<0.05	<0.17	<0.05	na	0.205	<1.2	28.2	<2	14.7	203	183	1690	3090	8830
Frankfurters, beef, boiled (28)	<0.010	<0.05	<0.17	nd	na	0.096	<1.2	23.0	<2	13.4	130	200	1330	1210	7900
Bologna, sliced (29)	<0.010	<0.05	nd	nd	na	0.137	<1.2	14.2	<2	11.3	154	532	1790	1770	10200

Table 4. (*continued*)

TDS food name[b] (No.)	Mean concentration, mg/kg														
	Cd	Pb	Ni[c]	As	Hg[d]	Se	Cu	Zn	Mn	Fe	Mg	Ca	P	K	Na
Ham luncheon meat (239)	<0.010	<0.05	nd	<0.04	na	0.236	<0.9	18.4	<1	7.0	176	51	2260	2750	10500
Salami, sliced (30)	<0.010	<0.05	nd	nd	na	0.204	<1.2	21.2	<2	16.7	185	362	1860	2530	13300
Liver, beef, fried (27)	0.077	<0.05	nd	<0.04	<0.04	0.596	111	54.0	3.7	61.6	229	50	4520	3450	734
Chicken breast, roasted (240)	<0.007	<0.04	nd	<0.04	nd	0.271	<0.9	9.1	nd	5.2	285	157	2200	3080	595
Chicken, fried, homemade (24)	<0.007	<0.04	nd	<0.04	nd	0.253	<0.9	18.7	<1	12.2	266	183	2070	3120	996
Chicken nuggets, fast-food (241)	<0.007	<0.04	0.169	<0.04	nd	0.201	<0.9	8.6	1.4	7.3	252	156	2250	2570	6630
Chicken, fried, fast-food (242)	<0.007	<0.04	<1.2	<0.04	nd	0.219	<0.9	12.4	1.0	9.9	236	546	1970	2460	5650
Turkey breast, roasted (26)	<0.005	nd	<0.09	<0.04	nd	0.355	<0.9	14.0	<1	4.7	307	80	2540	3500	1530
Fish sticks, frozen, heated (34)	0.012	<0.04	0.144	0.867	<0.04	0.165	<1	4.3	2.1	9.2	298	225	1790	2350	4450
Haddock, pan-cooked (243)	<0.007	<0.04	nd	5.33	0.072	0.397	<1	4.7	<1	<3	330	221	2170	3690	1360
Tuna, canned in oil (32)	0.020	<0.04	<0.12	0.942	0.170	0.650	<1	6.3	<1	9.1	289	122	1790	2390	2850
Shrimp, boiled (244)	0.013	<0.04	nd	0.830	<0.04	0.390	2.34	16.2	<1	14.3	426	1220	1850	955	2780
Legumes and nuts															
Pork and beans, canned (39)	<0.005	<0.03	0.424	<0.04	na	<0.04	1.8	7.6	3.4	14.7	313	417	910	2450	3190
Kidney beans, dry, boiled (245)	<0.005	<0.03	0.368	<0.04	na	<0.04	2.6	10.0	4.9	19.8	423	329	1450	4160	<30
Pinto beans, dry, boiled (38)	0.005	<0.03	0.555	<0.04	na	0.073	2.3	9.2	5.1	18.5	496	456	1470	4370	<30
Peas, mature, dry, boiled (246)	<0.005	<0.03	0.699	<0.04	na	<0.04	2.3	10.4	4.0	17.1	414	181	1360	3180	<30
Peanuts, dry roasted (48)	0.051	nd	0.956	<0.05	na	<0.05	5.8	29.5	19.9	17.1	1840	456	3740	6900	4720
Peanut butter, smooth (47)	0.056	<0.05	0.711	<0.05	na	0.081	5.2	27.1	16.5	17.8	1740	432	3540	6320	4040
Mixed nuts, no peanuts (247)	<0.010	<0.05	3.04	<0.05	na	0.579	15.5	41.0	23.2	41.6	2380	1050	4480	5780	2830
Grain products															
White bread (58)	0.018	<0.04	0.159	nd	nd	0.200	<1.2	6.2	4.2	30.3	223	1030	910	1210	5180
Whole wheat bread (62)	0.024	<0.04	0.186	<0.04	na	0.330	2.3	16.3	18.2	28.3	737	891	1930	2230	5080
Cracked wheat bread (248)	0.021	<0.04	0.152	<0.04	na	0.295	1.8	11.7	11.1	31.8	479	858	1460	1690	5040
Rye bread (64)	0.016	<0.04	<0.12	<0.04	na	0.258	1.5	9.6	7.0	27.3	364	718	1210	1640	6220
White roll (59)	0.018	<0.04	<0.12	nd	na	0.261	1.3	8.1	4.6	31.9	256	739	1120	1280	5180
Bagel, plain (249)	0.019	<0.04	<0.12	nd	na	0.308	1.3	7.7	4.4	30.3	255	769	941	1020	4670
English muffin, toasted (250)	0.021	<0.04	<0.12	<0.04	na	0.277	1.2	7.8	4.4	33.8	244	1910	1430	1350	4940
Biscuit, baked (61)	0.019	<0.04	<0.12	nd	na	0.121	<0.9	4.0	3.7	23.5	165	367	4470	2470	9850
Cornbread, homemade (60)	0.008	<0.04	0.216	<0.04	na	0.118	<0.9	6.0	2.0	15.5	186	1080	1500	1360	4410

Table 4. (*continued*)

TDS food name[b] (No.)	Mean concentration, mg/kg														
	Cd	Pb	Ni[c]	As	Hg[d]	Se	Cu	Zn	Mn	Fe	Mg	Ca	P	K	Na
Tortilla, flour (63)	0.018	<0.04	<0.12	<0.04	na	0.220	1.1	5.4	4.8	22.2	219	1350	1630	1380	6070
Blueberry muffin (65)	0.008	<0.04	<0.12	nd	na	0.117	<0.9	4.1	3.9	12.9	120	492	1800	1130	3790
Graham crackers (251)	0.030	<0.04	0.156	<0.04	na	0.052	1.5	7.8	8.5	35.4	322	575	1510	1650	5410
Saltine crackers (66)	0.028	<0.05	<0.17	nd	na	0.098	1.4	6.8	7.0	53.6	240	950	1060	1390	10900
Butter-type crackers (252)	0.026	<0.04	0.151	<0.04	na	0.058	1.0	5.3	5.1	38.4	195	1190	2410	1030	7500
Pancake from mix (68)	0.010	<0.04	<0.12	<0.04	na	0.124	<0.9	6.1	2.7	14.6	176	1200	3090	1560	5610
Macaroni, boiled (70)	0.028	<0.03	<0.09	nd	na	0.243	0.9	4.3	2.8	11.3	164	67	516	402	<30
Egg noodles, boiled (69)	0.027	<0.03	<0.09	nd	na	0.215	<1.2	5.6	2.8	13.3	184	114	684	343	54
Corngrits, regular, cooked (53)	<0.005	<0.03	<0.09	nd	na	<0.04	<0.9	1.2	<1	8.1	60	<10	175	262	84
Oatmeal, cooked (51)	<0.005	<0.03	0.495	nd	<0.04	0.055	<0.9	5.2	7.5	10.6	252	137	730	633	35
White rice, cooked (50)	0.007	<0.03	<0.09	0.066	nd	0.057	<0.9	4.8	4.4	12.5	89	54	357	227	30
Wheat cereal, farina, cooked (52)	0.006	<0.03	<0.09	nd	na	0.066	<0.9	1.9	1.8	42.3	70	237	393	230	228
Raisin bran cereal (74)	0.047	<0.04	0.436	<0.04	na	<0.04	4.5	103	28.8	340	1430	461	3720	5990	4890
Fruit-flavored, cereal (72)	0.009	<0.04	0.430	<0.04	nd	0.079	1.0	140	7.3	180	283	279	1000	1120	4890
Corn flakes (71)	<0.007	<0.04	<0.12	nd	na	0.049	<0.9	8.1	1.2	196	85	28	390	900	10100
Oat ring cereal (77)	0.015	<0.04	2.32	<0.04	na	0.244	3.3	122	33.8	340	1170	1630	4040	3180	9400
Shredded wheat cereal (73)	0.057	nd	0.216	<0.04	na	0.046	3.8	28.1	25.0	38.4	1210	379	3550	3830	<30
Crisped rice cereal (75)	0.007	<0.04	0.338	0.128	nd	0.076	2.0	17.9	13.1	101	313	83	1120	1250	10300
Granola cereal (76)	0.019	<0.04	1.01	<0.04	na	0.148	3.1	96.5	20.1	110	920	620	2660	3600	2580
Fruit															
Grapefruit, raw (92)	<0.004	<0.02	<0.06	nd	na	<0.03	<0.7	<1	<1	<2	89	206	164	1380	<20
Orange, raw (79)	nd	<0.03	<0.09	nd	na	nd	<0.7	<1	<1	<2	107	322	187	1580	<20
Prunes, dried (96)	<0.007	<0.04	0.387	<0.05	nd	nd	2.9	4.3	3.1	8.9	419	424	702	7280	<30
Raisins, dried (95)	<0.007	<0.04	0.163	<0.05	nd	nd	3.4	2.1	3.0	18.5	327	490	1010	7440	105
Applesauce, bottled (84)	nd	nd	<0.09	nd	na	nd	<0.7	<1	<1	<2	29	29	62	765	21
Apple, red, raw (78)	<0.005	<0.03	<0.09	<0.04	na	<0.04	<0.9	<1	<1	<3	50	46	99	1040	<30
Apricot, raw (253)	<0.005	<0.03	0.125	nd	na	nd	<0.9	1.8	<1	4.1	103	149	227	2610	<30
Avocado, raw (97)	0.027	<0.05	0.247	<0.05	nd	<0.05	2.2	6.1	<2	4.8	297	129	501	4980	49
Banana, raw (80)	nd	nd	<0.09	nd	na	<0.03	1.1	1.6	2.7	2.8	295	51	228	3510	<20
Cantaloupe, raw (89)	0.008	<0.02	0.071	<0.03	na	<0.03	<0.7	1.4	<1	<2	111	91	138	2610	174

Table 4. (*continued*)

TDS food name[b] (No.)	Mean concentration, mg/kg														
	Cd	Pb	Ni[c]	As	Hg[d]	Se	Cu	Zn	Mn	Fe	Mg	Ca	P	K	Na
Sweet cherries, raw (94)	nd	<0.02	nd	<0.04	na	nd	<0.9	<1	<1	<3	131	137	239	2380	<30
Grapes, seedless, raw (88)	<0.004	<0.02	<0.06	nd	na	nd	1.1	<1	<1	3.1	70	98	193	1820	<20
Peach, raw (83)	<0.005	<0.03	0.099	<0.03	na	nd	<0.7	1.7	<1	2.2	87	53	202	1890	<20
Peach, canned (254)	<0.005	0.032	0.408	<0.04	na	nd	<0.9	<1	<1	4.9	52	34	101	1070	34
Pear, raw (85)	<0.005	<0.03	0.095	nd	na	nd	0.8	<1	<1	<2	68	91	108	1200	<20
Pear, canned in light syrup (255)	<0.005	<0.03	<0.09	nd	na	nd	<0.9	<1	<1	3.9	47	52	66	747	<30
Pineapple, canned in juice (93)	<0.003	0.013	0.668	<0.04	na	nd	<0.9	<1	10.0	<3	147	128	56	1130	<30
Plums, raw (91)	<0.004	<0.02	<0.06	nd	na	nd	<0.7	<1	<1	<2	69	51	164	1600	nd
Watermelon, raw (81)	<0.004	nd	0.074	nd	na	<0.03	<0.7	<1	<1	2.5	99	72	113	1040	<20
Strawberries, raw (86)	0.016	<0.02	0.070	<0.03	na	<0.03	<0.7	1.0	3.6	4.1	123	149	252	1510	<20
Fruit cocktail, canned (87)	<0.005	0.031	<0.09	<0.04	na	nd	<0.9	<1	1.0	<3	53	58	98	967	35
Grapefruit juice, from conc. (100)	nd	nd	<0.05	<0.03	na	nd	<0.7	<1	<1	<2	102	123	161	1460	21
Orange juice, from conc. (98)	<0.003	<0.02	nd	nd	nd	nd	<0.7	<1	<1	<2	103	109	174	1720	<20
Pineapple juice, from conc. (256)	<0.003	<0.02	0.109	<0.03	na	nd	<0.7	<1	9.7	<2	136	131	79	1140	<20
Apple juice, bottled (99)	nd	<0.02	<0.05	<0.03	nd	<0.03	<0.7	<1	<1	<2	45	69	66	975	32
Grape juice, from conc. (257)	nd	<0.02	<0.05	<0.03	na	nd	<0.7	<1	1.6	<2	60	76	70	342	26
Prune juice, bottled (103)	<0.004	<0.02	0.095	<0.03	na	nd	<0.7	2.0	1.2	6.2	136	110	197	2370	42
Vegetables															
White potato, baked, skin (137)	0.039	<0.03	0.097	<0.03	na	<0.03	1.0	3.2	2.0	9.1	243	111	602	4730	28
White potato, boiled, no skin (136)	0.028	nd	<0.09	nd	na	nd	<0.8	2.1	1.2	2.9	158	56	430	2810	<20
Scalloped potatoes (139)	0.020	<0.04	<0.12	nd	na	<0.04	<1	3.5	1.1	3.3	186	508	740	3150	1940
French fries, fast-food (258)	0.053	<0.05	0.206	<0.04	na	nd	1.5	4.6	2.5	9.1	344	153	1290	5960	2610
French fries, frozen, heated (134)	0.034	<0.04	<0.12	nd	na	nd	1.1	3.2	1.8	6.0	241	98	935	4290	712
Mashed potatoes, flakes (135)	0.022	nd	<0.09	nd	na	<0.04	<1	2.1	<1	<3	146	341	534	2250	1050
Spinach, boiled (107)	0.125	<0.03	<0.09	<0.03	<0.04	<0.03	0.8	4.2	5.5	21.9	452	977	308	1960	397
Collards, boiled (108)	0.039	<0.03	<0.09	nd	nd	<0.03	<0.7	2.2	4.5	8.2	209	1380	304	1240	148
Broccoli, boiled (113)	0.014	<0.03	<0.09	nd	na	<0.04	<0.9	1.8	1.4	3.9	110	307	403	1410	134
Carrot, fresh, boiled (259)	0.020	<0.03	<0.09	<0.04	na	<0.04	<0.9	1.8	1.1	<3	87	265	272	2070	512
Winter squash, baked (126)	0.008	<0.03	0.190	nd	na	<0.04	<0.9	2.1	1.1	3.5	166	208	283	2940	<30
Sweet potato, fresh, baked (140)	0.008	<0.03	0.115	<0.03	na	<0.03	1.4	2.7	4.0	4.2	225	241	447	4330	222

Table 4. (*continued*)

TDS food name[b] (No.)	Mean concentration, mg/kg														
	Cd	Pb	Ni[c]	As	Hg[d]	Se	Cu	Zn	Mn	Fe	Mg	Ca	P	K	Na
Tomato, red, raw (117)	0.011	nd	<0.06	nd	nd	nd	<0.9	1.3	1.0	<3	103	83	249	2210	<30
Tomato, stewed, canned (260)	0.016	<0.03	0.187	nd	na	nd	<0.9	1.3	<1	13.6	115	315	190	2120	2240
Tomato juice, bottled (261)	0.016	<0.02	0.151	nd	na	<0.04	<0.9	1.1	<1	3.6	112	105	180	2230	2770
Tomato sauce, bottled (119)	0.025	<0.04	<0.12	<0.04	na	<0.04	1.2	1.7	1.0	8.2	157	148	269	3200	5140
Green beans, boiled (121)	<0.005	<0.03	0.133	nd	na	nd	<0.9	2.1	2.7	6.0	187	400	284	1460	<30
Lima beans, boiled (42)	<0.005	<0.03	0.532	<0.04	na	<0.04	1.5	6.2	5.9	15.6	377	244	945	2740	312
Beets, boiled (262)	0.020	<0.03	<0.09	<0.04	na	nd	<0.9	3.4	3.3	4.2	235	129	331	3100	709
Brussels sprouts, boiled (263)	0.007	<0.03	<0.09	<0.04	na	<0.04	<0.9	2.4	2.1	4.8	182	261	562	2900	154
Cabbage, fresh, boiled (110)	0.005	nd	<0.06	<0.03	na	<0.03	nd	<1	1.1	<2	81	308	179	1120	86
Coleslaw with dressing (111)	<0.007	<0.04	<0.12	nd	na	<0.05	<1.2	<2	<2	3.1	100	301	253	1450	3710
Sauerkraut, canned (112)	<0.005	<0.03	<0.09	nd	na	<0.04	<0.9	1.1	1.1	4.3	103	343	180	1610	5770
Asparagus, boiled (115)	0.010	<0.03	0.108	nd	na	0.047	1.0	3.8	1.3	4.9	100	182	463	1680	39
Cauliflower, boiled (116)	0.009	<0.03	<0.09	nd	nd	<0.04	<0.9	1.5	1.2	<3	91	151	323	1360	140
Celery, raw (114)	0.041	<0.02	<0.06	nd	na	<0.04	<0.9	<1	<1	<3	92	324	230	2600	731
Corn, boiled (54)	<0.005	<0.03	<0.09	nd	na	<0.04	<0.9	3.9	<1	3.1	185	29	595	1690	<30
Cream-style corn, canned (56)	<0.005	<0.03	<0.09	nd	na	<0.04	<0.9	2.8	<1	<3	130	32	375	1170	2800
Cucumber, raw (123)	<0.004	<0.02	<0.06	<0.04	na	nd	<0.9	1.1	<1	<3	109	127	210	1450	<30
Iceberg lettuce, raw (109)	0.066	nd	0.130	<0.03	na	<0.03	<0.7	1.3	1.2	3.2	78	170	227	1610	116
Mushrooms, raw (264)	0.007	<0.03	nd	0.070	nd	0.099	2.2	3.6	<1	<3	77	21	686	2700	36
Onion, mature, raw (128)	0.016	<0.03	<0.09	<0.04	na	<0.04	<0.9	1.5	1.2	<3	92	190	301	1430	33
Green peas, boiled (46)	<0.005	<0.03	0.586	nd	na	<0.04	1.0	6.1	2.7	14.1	212	232	783	1040	537
Green pepper, raw (125)	0.018	<0.03	0.103	nd	na	nd	<0.9	1.2	1.1	<3	96	87	195	1620	<30
Summer squash, boiled (124)	<0.005	<0.03	<0.09	<0.04	na	nd	<0.9	1.8	1.4	<3	133	185	260	1600	<30
Radish, raw (132)	0.009	nd	nd	<0.04	na	nd	<0.9	1.1	<1	<3	82	194	165	2070	286
Eggplant, fresh, boiled (265)	0.016	<0.03	<0.09	nd	na	nd	<0.9	1.0	1.0	<3	96	62	152	1210	<30
Turnip, boiled (266)	0.016	nd	nd	nd	na	<0.04	<0.9	1.2	<1	<3	86	332	262	1770	157
Okra, boiled (267)	0.019	<0.03	<0.09	<0.04	na	<0.04	<0.9	4.3	2.9	<3	359	799	330	1360	62
Mixed vegetables, boiled (268)	0.007	<0.03	0.172	<0.04	na	<0.04	<0.9	3.5	2.1	7.6	182	227	505	1410	231
Mixed dishes and meals															
Beef stew (143)	0.016	<0.03	<0.09	nd	na	0.072	<0.9	22.8	<1	9.9	167	132	856	2830	1830

Table 4. (*continued*)

TDS food name[b] (No.)	Mean concentration, mg/kg														
	Cd	Pb	Ni[c]	As	Hg[d]	Se	Cu	Zn	Mn	Fe	Mg	Ca	P	K	Na
Beef stroganoff (269)	0.014	<0.03	nd	<0.04	na	0.194	1.2	16.3	1.5	15.6	187	191	1180	1920	1050
Green peppers, stuffed (270)	0.011	<0.03	<0.09	<0.04	na	0.067	<0.9	13.9	1.6	10.4	121	134	702	1580	1070
Meatloaf, homemade (148)	<0.007	<0.04	<0.12	<0.04	na	0.201	<0.9	45.1	<1	23.2	198	241	1700	2820	4600
Chili con carne with beans (271)	0.007	<0.04	0.218	<0.04	na	0.054	1.4	19.9	2.1	18.3	252	381	1140	2920	3250
Chicken potpie, frozen (152)	0.011	<0.04	<0.12	nd	na	0.068	<0.8	4.5	1.9	9.3	127	190	772	1150	4140
Tuna noodle casserole (272)	0.016	<0.03	<0.09	0.106	<0.04	0.166	<1	5.9	1.2	7.0	147	699	1080	1200	3890
Lasagna with meat (151)	0.018	<0.04	<0.12	nd	na	0.140	1.0	15.3	1.5	13.2	207	1180	1530	2210	3580
Spaghetti and meatballs (142)	0.020	nd	<0.12	nd	na	0.124	1.0	8.4	1.7	13.6	170	293	647	2100	2060
Salisbury steak, frozen meal (273)	0.009	<0.03	0.261	<0.04	na	<0.04	<0.9	9.3	1.6	9.0	188	209	948	1970	3400
Turkey, frozen meal (274)	0.010	<0.03	<0.09	<0.04	na	0.101	<0.9	6.7	1.1	8.0	162	207	931	1700	3700
Macaroni and cheese, box (146)	0.016	<0.04	<0.12	nd	na	0.182	<1	5.4	2.1	8.9	182	558	1370	1040	3110
Spaghetti, canned (149)	0.014	<0.03	0.387	<0.04	na	0.104	<0.9	3.1	1.3	9.0	115	135	338	1030	3470
Cheeseburger, fast-food (275)	0.010	<0.04	<0.12	<0.04	na	0.174	<0.9	27.0	1.7	21.4	222	1300	1580	2090	5150
Hamburger, fast-food (147)	0.011	<0.04	<0.12	nd	na	0.175	0.9	27.5	1.9	24.6	220	774	1230	2180	3510
Fish sandwich, fast-food (276)	0.011	<0.04	<0.12	0.568	<0.04	0.192	<1	5.7	2.2	13.9	244	961	1310	1830	4810
Frankfurter, fast-food (277)	0.011	<0.04	<0.12	nd	na	0.196	<1.2	14.6	2.3	20.7	192	618	1250	1520	7380
Egg/cheese/ham, fast-food (278)	0.009	<0.04	<0.12	<0.04	na	0.271	<0.9	13.5	2.2	22.9	209	1830	2200	1610	6000
Taco or tostada, carry-out (279)	0.016	<0.04	0.140	<0.04	na	0.102	1.1	24.2	2.3	15.9	338	925	1680	2440	3940
Cheese pizza, carry-out (280)	0.016	<0.04	<0.12	nd	na	0.253	1.1	17.4	3.2	23.2	283	2270	2150	1750	5330
Pepperoni pizza, carry-out (281)	0.015	<0.04	<0.12	<0.04	na	0.244	1.1	17.7	3.4	22.8	274	1990	1990	1900	6280
Beef chow mein, carry-out (282)	0.011	<0.03	<0.09	<0.04	nd	0.067	<0.9	11.4	1.5	12.3	126	188	515	1340	3610
Bean soup, canned (283)	<0.005	<0.03	0.339	nd	na	<0.04	1.2	4.0	2.5	9.2	205	273	628	1610	3470
Chicken noodle soup, canned (155)	<0.005	<0.03	0.162	nd	na	<0.03	<0.8	1.1	<1	2.1	43	43	144	215	3790
Tomato soup, canned (156)	0.008	<0.03	0.177	nd	na	<0.03	<0.8	1.0	<1	3.8	68	60	139	1200	2720
Mushroom soup, canned (284)	<0.005	<0.03	0.247	<0.04	nd	<0.04	<0.9	2.8	<1	<3	78	638	598	1230	3600
Vegetable beef soup, canned (157)	0.009	<0.03	0.108	nd	na	<0.04	<0.9	3.4	<1	3.8	57	75	208	767	3140
Clam chowder, canned (285)	0.014	<0.03	0.099	0.138	nd	<0.04	<1	4.1	<1	4.6	122	596	612	1330	3610
Desserts															
Choc. milkshake, fast-food (7)	<0.005	<0.03	0.109	nd	na	<0.04	<0.9	4.7	<1	3.1	170	1170	1040	2060	773
Vanilla ice cream (286)	nd	<0.03	<0.09	nd	na	<0.04	<0.9	3.6	<1	<3	127	1090	949	1850	655

Table 4. (*continued*)

TDS food name[b] (No.)	Mean concentration, mg/kg														
	Cd	Pb	Ni[c]	As	Hg[d]	Se	Cu	Zn	Mn	Fe	Mg	Ca	P	K	Na
Vanilla light ice cream (177)	nd	<0.03	nd	nd	nd	<0.04	nd	3.9	nd	<3	146	1220	1060	2110	753
Fruit flavored sherbet (287)	<0.004	<0.02	<0.06	nd	na	<0.04	<0.9	1.1	<1	<3	53	353	299	647	292
Instant chocolate pudding (175)	0.008	<0.03	0.190	nd	na	<0.04	<0.9	4.3	<1	5.6	178	912	2320	1980	3000
Popsicle, any flavor (288)	nd	<0.04	<0.12	nd	na	<0.04	nd	<1	<1	<3	19	59	<40	61	98
Chocolate cake and icing (178)	0.015	<0.03	0.585	nd	na	<0.05	2.1	5.4	2.9	19.1	297	426	1220	2150	3480
Yellow cake with white icing (179)	0.005	<0.03	<0.09	nd	na	<0.04	<1	2.2	<1	8.0	49	695	1490	541	3000
Chocolate snack cake (289)	0.020	<0.03	0.792	<0.05	na	<0.05	2.6	5.8	3.7	22.7	363	389	1090	2450	2930
Sweet roll or Danish (182)	0.011	<0.03	0.091	nd	na	0.131	<1.2	6.0	3.3	19.4	169	806	974	1230	3490
Cake doughnuts with icing (290)	0.011	<0.03	0.228	nd	na	0.101	<1	4.5	2.7	16.7	171	337	2030	1140	4100
Brownies, commercial (291)	0.022	<0.03	0.779	<0.04	na	0.042	2.7	6.7	4.3	24.8	387	248	1070	2060	2190
Sugar cookies, commercial (292)	0.013	<0.03	<0.09	nd	na	<0.04	<1	4.0	3.3	22.6	123	262	975	866	3440
Chocolate chip cookies (183)	0.028	<0.03	0.747	nd	na	<0.04	2.6	6.9	4.9	31.1	383	272	1020	1690	3300
Sandwich cookies creme filled (184)	0.017	<0.03	0.272	<0.04	na	<0.04	1.6	4.9	4.1	38.5	246	214	767	1260	3830
Apple pie (185)	<0.007	<0.04	<0.12	<0.04	na	<0.04	<1	1.7	1.8	6.4	71	102	264	713	2470
Pumpkin pie (186)	<0.007	<0.04	0.121	nd	na	<0.04	<1	4.4	2.4	9.2	154	601	808	1880	2660
Milk chocolate candy bar (187)	0.031	<0.04	0.871	nd	na	0.043	4.1	13.4	3.4	13.0	658	1880	2150	4030	702
Caramel candy (188)	<0.007	<0.04	<0.12	nd	na	<0.04	<1	4.3	nd	<3	162	1280	1150	2310	2290
Suckers, any flavor (293)	<0.010	<0.05	<0.17	nd	na	<0.04	<1	<1	nd	<3	21	59	<40	47	471
Gelatin dessert, any flavor (190)	nd	<0.03	<0.09	<0.04	na	<0.04	nd	nd	nd	<3	<10	11	194	<30	486
Snacks															
Potato chips (138)	0.062	<0.05	0.231	<0.04	na	<0.04	2.8	9.7	4.5	14.4	648	196	1600	13000	4550
Corn chips (67)	<0.010	<0.05	<0.17	nd	na	<0.04	1.1	13.9	3.4	13.5	789	1150	1980	1560	4840
Popcorn, popped in oil (57)	<0.010	<0.05	0.253	nd	na	0.073	1.7	21.4	8.3	21.7	1110	43	2500	2340	<30
Pretzels, hard, salted (294)	0.021	<0.05	<0.17	<0.04	na	<0.04	1.6	9.1	9.3	39.4	295	292	1190	1540	17700
Condiments and sweeteners															
Tomato catsup (173)	0.024	<0.04	<0.12	nd	na	<0.03	1.5	1.9	1.1	4.7	176	159	309	3580	11000
White sugar, granulated (169)	<0.012	<0.06	nd	nd	na	nd	nd	<1	nd	<3	nd	<20	nd	<30	<30
Pancake syrup (170)	<0.007	<0.04	nd	nd	na	nd	nd	<1	<1	<3	20	33	90	152	826
Honey (172)	<0.007	<0.04	<0.12	nd	na	nd	nd	1.1	<1	4.2	13	45	<40	292	<30
Chocolate syrup (295)	0.029	<0.03	1.04	nd	na	<0.04	3.5	6.7	3.8	16.3	492	235	741	1940	579

Table 4. (*continued*)

TDS food name[b] (No.)	Mean concentration, mg/kg														
	Cd	Pb	Ni[c]	As	Hg[d]	Se	Cu	Zn	Mn	Fe	Mg	Ca	P	K	Na
Jelly, any flavor (296)	<0.005	<0.03	<0.09	<0.04	na	<0.04	<1	<1	1.2	<3	56	67	71	433	315
Sweet cucumber pickles (297)	<0.005	0.036	<0.09	<0.04	na	<0.04	<0.9	<1	<1	3.4	47	373	98	447	4860
Dill cucumber pickles (161)	<0.007	<0.04	<0.12	<0.04	na	nd	<0.9	<1	<1	3.1	60	457	111	775	8480
Yellow mustard (298)	0.027	<0.03	<0.09	<0.04	na	0.321	<0.9	6.4	4.1	14.7	499	583	1030	1350	11300
Black olives (299)	nd	<0.03	0.096	<0.04	na	nd	1.4	1.3	<1	38.5	44	649	51	42	7160
Fats and dressings															
Half & half cream (167)	<0.010	nd	nd	nd	na	<0.04	nd	3.1	nd	<3	95	885	820	1400	543
Cream substitute, frozen (168)	<0.007	<0.04	<0.12	nd	na	nd	nd	<1	nd	<3	13	39	484	717	555
Sour cream (300)	nd	<0.04	nd	nd	na	<0.04	nd	3.7	nd	<3	110	1040	902	1530	560
White sauce, homemade (160)	<0.007	<0.04	nd	nd	na	<0.03	<0.7	3.7	<1	4.2	111	913	806	1410	3600
Brown gravy, homemade (301)	<0.007	<0.04	<0.12	<0.04	na	<0.04	<0.9	5.2	<1	12.5	194	56	1450	3560	1770
Mayonnaise (166)	<0.024	<0.12	nd	nd	na	<0.05	nd	<2	nd	<3	<14	78	248	102	5040
French salad dressing (302)	<0.024	<0.12	nd	<0.04	na	<0.04	<1	<1	<1	<3	58	85	139	611	6870
Ital. salad dressing, low-cal (303)	<0.008	<0.04	nd	<0.04	na	nd	nd	<1	<1	<3	32	87	113	701	13300
Butter, regular (salted) (164)	<0.024	nd	nd	<0.04	na	nd	nd	<1	nd	<3	17	234	229	237	5760
Margarine, stick (salted) (162)	<0.024	<0.12	<0.42	nd	na	nd	nd	<1	nd	<3	14	54	96	221	7380
Olive or safflower oil (304)	nd	nd	nd	<0.04	na	nd	nd	<1	nd	<3	<12	<20	<40	<30	<30
Beverages															
Tap water (201)	nd	nd	nd	nd	na	nd	<0.2	<0.4	nd	<0.5	8	31	<10	<5	28
Coffee, from ground (305)	<0.003	<0.02	nd	nd	na	nd	nd	<1	<1	nd	26	15	<30	367	<20
Coffee, decaff., instant (196)	nd	<0.02	<0.05	nd	na	<0.013	nd	<0.4	<0.4	<1	48	25	42	462	15
Tea, from tea bag (197)	nd	nd	<0.05	nd	na	<0.013	nd	<0.4	2.9	nd	11	<4	<20	176	10
Cola carbonated (191)	nd	nd	nd	nd	na	nd	nd	<1	nd	<2	<9	27	146	<30	33
Fruit-flavored carbonated (306)	nd	nd	nd	nd	na	nd	nd	<1	nd	nd	<8	30	<30	35	69
Low-calorie cola carbonated (194)	nd	nd	nd	nd	na	nd	nd	<1	nd	nd	<8	33	107	65	50
Lemonade, conc. (105)	nd	nd	nd	nd	na	<0.03	nd	<1	nd	<2	14	21	<30	214	<20
Fruit drink, from powder (193)	nd	nd	nd	nd	na	<0.03	nd	nd	nd	nd	31	96	49	<20	26
Fruit drink, canned (307)	<0.003	nd	nd	<0.03	na	<0.03	nd	<1	<1	<2	32	131	49	313	46
Beer (198)	nd	nd	nd	nd	na	<0.03	nd	<1	<1	nd	58	42	144	245	31
Martini (308)	nd	<0.02	nd	nd	na	nd	<0.4	<0.4	<0.4	<1	<4	<4	<20	28	<10

Table 4. (*continued*)

TDS food name[b] (No.)	Mean concentration, mg/kg														
	Cd	Pb	Ni[c]	As	Hg[d]	Se	Cu	Zn	Mn	Fe	Mg	Ca	P	K	Na
Dry table wine (199)	nd	0.023	<0.05	<0.02	na	<0.02	<0.5	<0.5	1.1	2.8	87	79	122	799	40
Whiskey (200)	nd	<0.02	nd	nd	na	nd	<0.4	nd	nd	<1	<5	<5	<20	<20	<10
Infant and junior foods															
Milk-based formula, lo Fe (203)	<0.004	nd	nd	nd	nd	<0.04	<0.9	7.1	nd	<3	66	528	418	874	223
Milk-based formula, hi Fe (202)	nd	nd	nd	nd	nd	<0.04	<0.9	6.9	nd	13.6	65	518	408	863	219
Soy-based formula (309)	nd	nd	nd	<0.04	nd	<0.04	<0.9	6.7	<1	12.0	73	658	463	900	299
Egg yolk (310)	<0.007	<0.04	na	nd	nd	0.293	<0.9	22.2	<1	29.7	76	778	2950	643	380
Beef (205)	<0.005	<0.03	<0.09	nd	na	<0.04	<0.9	31.2	<1	14.2	133	59	1080	2090	436
Chicken (207)	<0.005	<0.03	<0.09	<0.04	nd	0.131	<0.9	12.5	nd	11.1	152	1060	1520	1640	476
Rice cereal, instant (311)	<0.007	<0.04	<0.12	0.041	na	0.051	<0.9	6.4	4.5	117	189	2150	1690	1390	309
Rice cereal (312)	<0.005	<0.03	<0.09	<0.04	na	<0.04	<0.9	1.9	1.3	59.6	50	131	186	502	82
Applesauce (225)	<0.005	<0.03	<0.09	<0.04	na	<0.04	<0.9	<1	<1	<3	41	39	73	875	<30
Peaches (226)	<0.005	<0.03	0.142	nd	na	nd	<0.9	<1	<1	<3	72	40	162	1730	<30
Pears (227)	<0.005	<0.03	0.133	nd	nd	nd	<0.9	<1	<1	<3	73	91	110	1180	<30
Apple juice, strained (230)	nd	nd	nd	<0.04	nd	nd	<0.9	<1	1.4	<3	44	47	67	959	<30
Orange juice, strained (231)	nd	nd	nd	nd	na	nd	<0.9	<1	<1	<3	113	118	175	1830	<30
Bananas with tapioca (313)	<0.005	nd	<0.09	nd	nd	nd	<0.9	<1	1.6	<3	123	41	97	1380	40
Fruit dessert or pudding (233)	<0.005	<0.03	<0.09	<0.04	na	nd	<0.9	<1	<1	<3	58	62	78	871	44
Custard pudding (232)	<0.005	nd	nd	nd	na	<0.04	nd	3.0	<1	<3	59	521	526	740	270
Creamed spinach (224)	0.090	<0.03	0.166	<0.04	nd	<0.04	<0.9	5.4	7.5	8.2	396	1050	580	1760	229
Carrots (218)	0.028	<0.03	0.162	<0.04	na	nd	<0.9	1.7	1.6	<3	96	230	227	2040	288
Sweet potatoes (221)	0.005	<0.03	0.112	nd	na	nd	0.9	1.8	2.6	<3	152	147	255	2620	108
Green beans (219)	<0.005	<0.03	0.209	nd	na	nd	<0.9	2.2	2.9	5.5	172	344	252	1450	65
Beets (314)	0.026	<0.03	na	nd	na	nd	<0.9	2.3	3.6	3.1	216	139	200	2800	292
Creamed corn (222)	<0.005	<0.03	<0.09	<0.04	na	<0.04	<0.9	2.5	1.2	<3	89	176	362	843	86
Mixed vegetables (220)	0.021	<0.03	0.137	<0.04	nd	<0.04	<0.9	2.0	1.7	3.2	105	150	265	1380	212
Peas (223)	<0.005	nd	0.211	<0.04	na	<0.04	0.9	5.5	2.5	10.3	194	176	563	1170	91
Vegetables and beef (211)	0.014	<0.03	0.093	<0.04	nd	<0.04	<0.9	4.1	1.1	3.7	85	100	287	1200	303
Vegetables and chicken (212)	0.015	<0.03	0.129	<0.04	na	<0.04	<0.9	3.1	1.2	3.4	81	232	339	944	275
Vegetables and ham (213)	0.011	<0.03	0.132	<0.04	na	<0.04	<0.9	2.6	1.2	<3	73	100	267	878	198

Table 4. (*continued*)

TDS food name[b] (No.)	Mean concentration, mg/kg														
	Cd	Pb	Ni[c]	As	Hg[d]	Se	Cu	Zn	Mn	Fe	Mg	Ca	P	K	Na
Beef with vegetables (209)	0.005	<0.03	na	nd	na	nd	<0.9	13.3	<1	7.2	90	72	520	1310	183
Ham with vegetables (210)	0.005	nd	na	nd	na	<0.14	<0.9	10.3	<1	6.0	117	79	665	1550	176
Chicken with vegetables (208)	0.005	<0.03	na	nd	na	<0.14	<0.9	6.5	<1	7.0	88	210	545	1200	266
Macaroni, tomatoes, beef (215)	0.015	<0.03	<0.09	<0.04	na	<0.04	<0.9	3.8	1.2	4.1	92	149	333	1230	238
Turkey and rice (216)	0.014	<0.03	<0.09	<0.04	na	<0.04	<0.9	4.5	1.3	<3	76	225	349	964	305
Chicken noodle dinner (214)	0.011	<0.03	0.116	<0.04	na	<0.04	<0.9	3.5	1.3	4.0	85	260	375	884	265
Split peas with veg., ham (316)	0.010	<0.03	0.102	<0.04	na	<0.04	<0.9	2.8	1.5	3.1	93	131	328	1170	529
Teething biscuits (317)	0.014	<0.04	0.152	<0.04	na	0.198	1.4	7.2	5.0	29.0	423	965	1470	3260	2390
Squash (320)	0.006	<0.03	0.127	na	na	na	na	na	na	na	na	na	na	na	na

[a] The number of samples per TDS food is normally 18 except for Ni which is normally 3; "<(value)" = mean concentration is less than limit of quantitation (value); nd = element was not detected in the TDS food from any market basket with the following nominal limits of detection (mg/kg): As, 0.01; Ca, 3; Cd, 0.002; Cu, 0.2; Fe, 0.5; Hg, 0.01; K, 6; Mg, 3; Mn, 0.2; Na, 5; Ni, 0.025; P, 8; Pb, 0.008; Se, 0.01; Zn, 0.2; na = TDS food was not analyzed.

[b] Food descriptions may be shortened; full food names are available in supplemental information (23).

[c] Analysis of TDS foods for nickel initiated with market basket 96-3.

[d] Only 47 TDS foods were analyzed for Hg.

tions from a single 1984 FDA TDS MB (26) were similar to current results.

Mean and median As concentrations in all TDS foods were 0.036 and 0 mg/kg, respectively. As was not detectable in about 88% of TDS foods and was at trace levels for another 7.8%. The individual TDS food with the highest As concentration was haddock (10.4 mg/kg in MB 96-3). The 5 TDS foods with the highest mean As concentrations were haddock (5.33 mg/kg), canned tuna (0.942 mg/kg), fish sticks (0.867 mg/kg), shrimp (0.830 mg/kg), and fish sandwiches (0.568 mg/kg). Quantifiable concentrations of As were consistently present in these foods. The mean As concentration of these TDS foods (or a very similar TDS food) from MBs 1982–1991 were cod or haddock (2.91 mg/kg), canned tuna (0.828 mg/kg), fish sticks (0.768 mg/kg), and shrimp (1.33 mg/kg). Fish sandwiches were not included in MBs 1982–1991. The As concentrations from MBs 1991–1996 were comparable to those of 1982–1991. The detection of As primarily in seafood was expected. The individual TDS food with the highest As concentration, excluding seafood, was infant carrots (0.400 mg/kg in MB 93-3). The 5 TDS foods with the highest mean As concentrations, excluding seafood, were crisped rice cereal (0.128 mg/kg), mushrooms (0.070 mg/kg), white rice (0.066 mg/kg), infant instant rice cereal (0.041 mg/kg), and infant carrots (0.035 mg/kg). Trace and non-detectable concentrations of As were consistently present in these foods. These results were similar to mean As concentrations from MBs 1982–1991 (or a very similar TDS food) except for the higher concentration in infant carrots in MBs 1991–1996. MBs 1982–1991 mean findings for As were crisped rice cereal (0.198 mg/kg), mushrooms (0.039 mg/kg), white rice (0.077 mg/kg), and infant carrots (0.004 mg/kg). Infant instant rice cereal was not included in MBs 1982–1991. For infant carrots in MBs 1991–1996, As was not detected in 16 of 18 MBs; the other 2 results had relatively high concentrations resulting in the high mean concentration. This relatively high level of As initiated regulatory follow-up.

Mean and median Hg concentrations in all 47 TDS foods analyzed were 0.006 and 0 mg/kg, respectively. Hg was not detectable in about 91% of TDS foods and was at trace levels for another 3.2%. The individual TDS food with the highest Hg concentration was canned tuna (0.322 mg/kg in MB 96-3). The 5 TDS foods with the highest mean Hg concentrations were canned tuna (0.170 mg/kg), haddock (0.072 mg/kg), shrimp (0.028 mg/kg), tuna noodle casserole (0.021 mg/kg), and fish sticks (0.006 mg/kg). Quantifiable concentrations of Hg were consistently present in the canned tuna and haddock but trace and non-detectable concentrations of Hg were consistently present in the other 3 foods. The mean Hg concentration of these TDS foods (or a very similar TDS food) from MBs 1982–1991 were canned tuna (0.268 mg/kg), cod or haddock (0.121 mg/kg), shrimp (0.025 mg/kg), and fish sticks (0.022 mg/kg). Tuna noodle casserole was not included in MBs 1982–1991. Hg concentrations from MBs 1991–1996 were comparable to those of 1982–1991. The finding of Hg primarily in seafood was expected. The individual TDS food, excluding seafood, with the highest Hg concentration was beef liver with a trace level (0.030 mg/kg in MB 96-3). Two other individual TDS foods had trace levels of Hg: spinach (0.018 mg/kg in MB 96-3) and oatmeal (0.012 mg/kg). No other individual TDS foods, excluding seafood, had a detectable concentration of Hg.

Mean and median Se concentrations in all TDS foods were 0.073 and 0.011 mg/kg, respectively. Se was not detectable in about 50% of TDS foods and was at trace levels for another 17%. The individual TDS food with the highest Se concentration was mixed nuts (1.80 mg/kg in MB 96-2). The 5 TDS foods with the highest mean Se concentrations were canned tuna (0.650 mg/kg), beef liver (0.596 mg/kg), mixed nuts (0.579 mg/kg), pork chop (0.453 mg/kg), and haddock (0.397 mg/kg). Quantifiable concentrations of Se were consistently present in these foods. These results were similar to the mean Se concentrations from MBs 1982–1991 (or a very similar TDS food): canned tuna (0.789 mg/kg), beef liver (0.575 mg/kg), pork chop (0.379 mg/kg), and cod or haddock (0.386 mg/kg). Mixed nuts were not included in MBs 1982–1991.

Mean and median Cu concentrations in all TDS foods were 1.2 and 0.5 mg/kg, respectively. Cu was not detectable in about 26% of TDS foods and was at trace levels for another 48%. The individual TDS food with the highest Cu concentration was beef liver (224 mg/kg in MB 96-3). The 5 TDS foods with the highest mean Cu concentrations were beef liver (111 mg/kg), mixed nuts (15.5 mg/kg), peanuts (5.8 mg/kg), peanut butter (5.2 mg/kg), and raisin bran cereal (4.5 mg/kg). Quantifiable concentrations of Cu were consistently present in these foods. These concentrations were similar to the mean Cu concentrations from MBs 1982–1991: beef liver (72.4 mg/kg), peanuts (6.1 mg/kg), peanut butter (5.6 mg/kg), and raisin bran cereal (5.0 mg/kg). Mixed nuts were not included in MBs 1982–1991.

Mean and median Zn concentrations in all TDS foods were 9.4 and 3.8 mg/kg, respectively. Zn was not detectable in about 8% of TDS foods and was at trace levels for another 15%. The individual TDS food with the highest Zn concentration was oat ring cereal (226 mg/kg in MB 94-4). The 5 TDS foods with the highest mean Zn concentrations were fruit-flavored cereal (140 mg/kg), oat ring cereal (122 mg/kg), raisin bran cereal (103 mg/kg), granola cereal (96.5 mg/kg), and beef chuck roast (79.6 mg/kg). Quantifiable concentrations of Zn were consistently present in these foods. The mean Zn concentrations of these foods from MBs 1982–1991 were fruit-flavored cereal (125 mg/kg), oat ring cereal (31.7 mg/kg), raisin bran cereal (92.8 mg/kg), granola cereal (25.9 mg/kg), and beef chuck roast (81.6 mg/kg). Zn concentrations from MBs 1991–1996 were comparable to those of 1982–1991, except for the higher concentrations in oat ring cereal and granola cereal from MBs 1991–1996. These higher concentrations may be due to an increase in Zn fortification of the product.

Mean and median Mn concentrations in all TDS foods were 2.4 and 1.0 mg/kg, respectively. Mn was not detectable in about 25% of TDS foods and was at trace levels for another

Table 5. Comparison of current FDA's Total Diet Study results for selected foods with previous TDS and other findings

	Concentration, mg/kg														
	Cd	Pb	Ni	As	Hg	Se	Cu	Zn	Mn	Fe	Mg	Ca	P	K	Na
Food name	Whole milk														
TDS 1991–97[a]	nd	<0.007	nd	nd	nd	0.018	nd	3.6	nd	<0.7	100	958	805	1400	369
TDS 1982–91[b]	<0.01	<0.02	—	<0.02	<0.01	<0.05	<0.05	3.7	<0.02	0.2	100	1010	800	1440	420
Literature[c]	0.0005	0.002	0.01	0.001	—	0.02	0.08	4	0.03	0.6	100	1000	900	1000	500
	Eggs, boiled														
TDS 1991–97[a]	nd	<0.007	nd	<0.01	nd	0.282	0.63	13.2	<0.3	18.5	121	618	2000	1200	1200
TDS 1982–91[b]	<0.01	<0.02	—	<0.02	<0.01	0.270	0.64	14.6	0.30	21.0	120	610	2000	1260	1220
Literature[c]	0.002	0.005	<0.1	0.006	—	0.3	0.1	10	0.30	20	100	500	2000	1000	1000
	Tuna, canned in oil														
TDS 1991–97[a]	0.020	<0.01	<0.036	0.942	0.17	0.650	0.5	6.3	0.3	9.1	289	122	1790	2390	2850
TDS 1982–91[b]	0.026	0.268	—	0.828	0.268	0.790	0.5	7.8	0.1	13.5	300	140	1690	2310	3380
Literature[c]	0.01	0.03	0.1	1	—	0.4	2	8	0.15	10	310	100	3000	2000	3000
	Peanut butter														
TDS 1991–97[a]	0.056	<0.014	0.711	<0.02	—	0.081	5.24	27.1	16.5	17.8	1740	432	3540	6320	4000
TDS 1982–91[b]	0.052	<0.02	—	<0.02	<0.01	<0.05	5.55	29.8	18.2	19.5	1670	420	3440	6340	4650
Literature[c]	0.05	0.009	2	0.02	—	0.07	5	30	10	20	2000	400	4000	5000	2000
	White bread														
TDS 1991–97[a]	0.018	<0.01	0.159	nd	nd	0.200	1.1	6.2	4.2	30.3	223	1030	910	1210	5180
TDS 1982–91[b]	0.021	<0.02	—	<0.02	<0.01	0.260	1.1	7.2	4.3	32.9	230	1040	940	1140	5310
Literature[c]	0.03	0.02	0.1	0.01	—	0.2	2	6	5	20	200	800	900	1000	5000
	Apple, red, raw														
TDS 1991–97[a]	<0.002	<0.007	<0.025	<0.01	—	<0.01	0.25	<0.3	<0.3	1.1	50	46	99	1040	8
TDS 1982–91[b]	<0.01	<0.02	—	<0.02	<0.01	<0.05	0.29	0.2	0.3	1.5	50	50	80	1020	10
Literature[c]	0.0003	0.006	0.03	0.004	—	0.008	0.5	1	0.5	3	60	70	100	1000	20

Table 5. (*continued*)

	Concentration, mg/kg														
	Cd	Pb	Ni	As	Hg	Se	Cu	Zn	Mn	Fe	Mg	Ca	P	K	Na
White potato, boiled w/o skin															
TDS 1991–97[a]	0.028	nd	0.061	nd	—	nd	0.6	2.1	1.2	2.9	158	56	430	2810	17
TDS 1982–91[b]	0.030	<0.02	—	<0.02	<0.01	<0.05	0.6	2.1	1.2	3.4	150	50	390	2680	20
Literature[c]	0.02	0.004	0.05	0.005	—	0.01	1	3	1	4	200	70	500	4000	40
Milk chocolate candy bar															
TDS 1991–97[a]	0.031	0.028	0.871	nd	—	0.043	4.1	13.4	3.4	13.0	658	1880	2150	4030	702
TDS 1982–91[b]	0.031	0.039	—	<0.02	<0.01	<0.05	4.4	14.4	3.3	14.9	620	1830	2050	3970	830
Literature[c]	0.01	0.05	2	0.03	—	0.04	10	20	3	20	700	2000	2000	4000	700
Potato chips															
TDS 1991–97[a]	0.062	<0.014	0.231	<0.02	—	0.025	2.8	9.7	4.5	14.4	648	196	1600	13000	4550
TDS 1982–91[b]	0.149	<0.02	—	<0.02	<0.01	<0.05	3.4	11.1	4.5	16.0	650	250	1540	13400	4730
Literature[c]	0.09	0.01	0.3	0.02	—	0.06	5	10	5	20	700	400	2000	10000	5000
Honey															
TDS 1991–97[a]	<0.002	0.025	<0.036	nd	—	nd	nd	1.1	0.3	4.2	13	45	36	292	21
TDS 1982–91[b]	<0.01	<0.02	—	<0.02	<0.01	<0.05	0.2	2.0	0.7	3.9	20	60	40	460	20
Literature[c]	0.0011	0.0178	0.01	0.005	—	0.008	0.6	3	0.6	10	40	50	100	500	60

[a] The number of samples per TDS food is normally 18 except for Ni which is normally 3; "<(value)" = mean concentration is less than limit of detection (value); nd = indicates element was not detected in the TDS food from any market basket with the following nominal limits of detection (mg/kg): As, 0.01; Ca, 3; Cd, 0.002; Cu, 0.2; Fe, 0.5; Hg, 0.01; K, 6; Mg, 3; Mn, 0.2; Na, 5; Ni, 0.025; P, 8; Pb, 0.008; Se, 0.01; Zn, 0.2.

[b] Na, P, and K, reference 27; Cu, Mn, and Se, reference 28; Ca, Mg, Fe, and Zn, reference 29. The number of samples per TDS food is normally 37; "<(value)" = mean concentration is less than limit of detection (value).

[c] Mean of values obtained from references 25, 30–32; rounded to one significant digit; some results from TDS 1982–1991 are included in compilation from reference 30.

24%. The individual TDS food with the highest Mn concentration was shredded wheat cereal (44.4 mg/kg in MB 94-1). The 5 TDS foods with the highest mean Mn concentrations were oat ring cereal (33.8 mg/kg), raisin bran cereal (28.8 mg/kg), shredded wheat cereal (25.0 mg/kg), mixed nuts (23.2 mg/kg), and granola cereal (20.1 mg/kg). Quantifiable concentrations of Mn were consistently present in these foods. These concentrations were similar to the mean Mn concentrations from MBs 1982–1991: oat ring cereal (38.7 mg/kg), raisin bran cereal (34.0 mg/kg), shredded wheat cereal (26.9 mg/kg), and granola cereal (26.6 mg/kg). Mixed nuts were not included in MBs 1982–1991.

Mean and median Fe concentrations in all TDS foods were 14.8 and 5.0 mg/kg, respectively. Fe was not detectable in about 10% of TDS foods and was at trace levels for another 26%. The individual TDS food with the highest Fe concentration was raisin bran cereal (550 mg/kg in MB 91-3). The 5 TDS foods with the highest mean Fe concentrations were oat ring cereal and raisin bran cereal (both 340 mg/kg), corn flakes (196 mg/kg), fruit-flavored cereal (180 mg/kg), and infant instant rice cereal (117 mg/kg). Quantifiable concentrations of Fe were consistently present in these foods. These concentrations were similar to the mean Fe concentrations from MBs 1982–1991: oat ring cereal (282 mg/kg), raisin bran cereal (343 mg/kg), corn flakes (110 mg/kg), and fruit-flavored cereal (177 mg/kg). Infant instant rice cereal was not included in MBs 1982–1991.

Mean and median Mg concentrations in all TDS foods were 208 and 139 mg/kg, respectively. Mg was not detectable in about 1.9% of TDS foods and was at trace levels for another 1.8%. The individual TDS food with the highest Mg concentration was mixed nuts (2940 mg/kg in MB 94-4). The 5 TDS foods with the highest mean Mg concentrations were mixed nuts (2380 mg/kg), peanuts (1840 mg/kg), peanut butter (1740 mg/kg), raisin bran cereal (1430 mg/kg), and shredded wheat cereal (1210 mg/kg). Quantifiable concentrations of Mg were consistently present in these foods. These concentrations were similar to the mean Mg concentrations from MBs 1982–1991: peanuts (1800 mg/kg), peanut butter (1670 mg/kg), raisin bran cereal (1470 mg/kg), and shredded wheat cereal (1210 mg/kg). Mixed nuts were not included in MBs 1982–1991.

Mean and median Ca concentrations in all TDS foods were 469 and 206 mg/kg, respectively. Ca was not detectable in about 0.8% of TDS foods and was at trace levels for another 1.4%. The individual TDS food with the highest Ca concentration was Swiss cheese (9890 mg/kg in MB 95-1). The 5 TDS foods with the highest mean Ca concentrations were Swiss cheese (7910 mg/kg), cheddar cheese (6880 mg/kg), American cheese (5510 mg/kg), cheese pizza (2270 mg/kg), and infant instant rice cereal (2150 mg/kg). Quantifiable concentrations of Ca were consistently present in these foods. These concentrations were similar to the mean Ca concentrations from MBs 1982–1991 (or a very similar TDS food): cheddar cheese (6030 mg/kg), American cheese (5280 mg/kg), and cheese pizza (2190 mg/kg). Swiss cheese and infant instant rice cereal were not included in MBs 1982–1991.

Mean and median P concentrations in all TDS foods were 968 and 610 mg/kg, respectively. P was not detectable in about 2.2% of TDS foods and was at trace levels for another 2.9%. The individual TDS food with the highest P concentration was American cheese (8360 mg/kg in MB 95-3). The 5 TDS foods with the highest mean P concentrations were Swiss cheese (5670 mg/kg), American cheese (5480 mg/kg), cheddar cheese (4580 mg/kg), beef liver (4520 mg/kg), and mixed nuts (4480 mg/kg). Quantifiable concentrations of P were consistently present in these foods. These concentrations were similar to the mean P concentrations from MBs 1982–1991: American cheese (5830 mg/kg), cheddar cheese (4550 mg/kg), and beef liver (4480 mg/kg). Swiss cheese and mixed nuts were not included in MBs 1982–1991.

Mean and median K concentrations in all TDS foods were 1840 and 1500 mg/kg, respectively. K was not detectable in about 1.4% of TDS foods and was at trace levels for another 1.7%. The individual TDS food with the highest K concentration was potato chips (15 000 mg/kg in MB 92-1). The 5 TDS foods with the highest mean K concentrations were potato chips (13 000 mg/kg), raisins (7440 mg/kg), prunes (7280 mg/kg), peanuts (6900 mg/kg), and peanut butter (6320 mg/kg). Quantifiable concentrations of K were consistently present in these foods. These concentrations were similar to the mean K concentrations from MBs 1982–1991: potato chips (13 400 mg/kg), raisins (7350 mg/kg), prunes (7190 mg/kg), peanuts (6860 mg/kg), and peanut butter (6340 mg/kg).

Mean and median Na concentrations in all TDS foods were 2240 and 626 mg/kg, respectively. Na was not detectable in about 7.2% of TDS foods and was at trace levels for another 13%. The individual TDS food with the highest Na concentration was pork bacon (29 800 mg/kg in MB 93-1). The 5 TDS foods with the highest mean Na concentrations were pork bacon (19 500 mg/kg), pretzels (17 700 mg/kg), American cheese (14 600 mg/kg), salami (13 300 mg/kg), and Italian salad dressing (13 300 mg/kg). Quantifiable concentrations of Na were consistently present in these foods. These concentrations were similar to the mean Na concentrations from MBs 1982–1991 (or a very similar TDS food): pork bacon (15 100 mg/kg), American cheese (15 200 mg/kg), salami (11 200 mg/kg), and Italian salad dressing (11 900 mg/kg). Pretzels were not included in MBs 1982–1991.

A limited examination was made to compare TDS results to element concentrations found in MBs 1982–1991 and literature values. The examination was limited to one food for 10 of the 14 food groups indicated in Table 4. No food was examined from mixed dishes and meals, infant and junior foods, and fats and dressings groups because their components are represented in other groups. The beverage group was not examined because few elements could be detected. Food selection within each group was made on the basis of mass intake, element concentrations, or availability of compiled values. The foods whole milk, eggs, white bread, apple, potato, and potato chips were selected because they had the highest aver-

age food mass intakes for the average diet. Although tuna, peanut butter, and milk chocolate did not have the greatest food mass intakes, they were selected because of the variety of element concentrations. Honey was selected even though it had the lowest food mass intake because it had the least amount of food processing, and compiled values were the most directly comparable. Granulated white sugar was not used because all elements were undetected. Table 5 compares results for selected TDS foods with results from MBs 1982–1991 (27–29) and other reported concentrations for similar foods (25, 30–32). Most of the results were consistent with MBs 1982–1991 and literature values; differences were small and not significant. The following differences were the most notable: lower literature concentration for Cu in eggs; higher literature concentration for Cu and higher MBs 1982–1991 concentration for Pb in canned tuna; higher literature concentrations for Ni and Cu in milk chocolate; higher MBs 1982–1991 concentration for Cd in potato chips. The higher Pb concentration in MBs 1982–1991 canned tuna can be attributed to use, at that time, of lead-soldered cans.

Radionuclides

All results indicated contaminant radionuclides were at very low levels. These trace amounts of radionuclides were consistent with the near disappearance of contamination from atmospheric testing of nuclear weapons during the early 1960s. Levels of ^{131}I and ^{106}Ru were below detection in all TDS foods analyzed. Levels of ^{137}Cs were below detection for all TDS foods except honey in MB 95-1 (6.7 Bq/kg). This finding was in agreement with past findings that ^{137}Cs levels are elevated in honey, presumably the result of natural concentration. This activity is about 200 times less than regulatory levels for ^{137}Cs in foods (1200 Bq/kg).

All MB 92-1 and 93-1 TDS foods were analyzed for ^{90}Sr. For MB 94-1 and 95-1, a limited number (about 60) of TDS foods were analyzed for ^{90}Sr. The TDS foods selected for analysis were those historically having the greatest ^{90}Sr levels. ^{90}Sr was detected in about 65% of these TDS foods. The activity concentrations were very low and consistent with past TDS results (33). The greatest ^{90}Sr concentration (2 Bq/kg) was in mixed nuts from MB 94-1 and is about 80 times less than regulatory levels (160 Bq/kg; 34).

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References

(1) Pennington, J.A.T., & Gunderson, E.L. (1987) *J. Assoc. Off. Anal. Chem.* **70**, 772–782

(2) Pennington, J.A.T., Capar, S.G., Parfitt, C.H., & Edwards, C.W. (1996) *J. AOAC Int.* **79**, 163–170

(3) Pennington, J.A.T. (1992) *J. Nutr. Ed.* **24**, 173–178

(4) Pennington, J.A.T. (1992) *Food Addit. Contam.* **9**, 253–264

(5) Pennington, J.A.T. (1992) *Appendices for the 1990 Revision of the Food and Drug Administration's Total Diet Study*, PB92-176239/AS, National Technical Information Service, Springfield, VA

(6) Capar, S.G. (1991) in *Biological Trace Element Research*, K.S. Subramanian, G.V. Iyengar, & K. Okamota (Eds), ACS Symposium Series 445, American Chemical Society, Washington, DC, Chapter 13, pp 181–195

(7) U.S. Food and Drug Administration (1996) *Contamination Control*, SOP KCM TD G1, FDA Kansas City District Laboratory, Lenexa, KS

(8) U.S. Food and Drug Administration (1996) *Quality Assurance*, SOP KCM TD G2, FDA Kansas City District Laboratory, Lenexa, KS

(9) U.S. Food and Drug Administration (1998) *Nitric Acid Solubilization and Direct Ashing Procedure for Lead, Cadmium and Nickel*, SOP KCM TD M5, FDA Kansas City District Laboratory, Lenexa, KS

(10) U.S. Food and Drug Administration (1998) *Determination of Lead, Cadmium and Nickel by GFAAS: Varian SpectrAA 400Z, 640Z, or 800Z*, SOP KCM TD E2, FDA Kansas City District Laboratory, Lenexa, KS

(11) U.S. Food and Drug Administration (1993) *Ternary Acid Digestion*, SOP KCM TD M2, FDA Kansas City District Laboratory, Lenexa, KS

(12) U.S. Food and Drug Administration (1993) *Multielement Determination by ICP: Applied Research Laboratories Model 3580*, SOP KCM TD E1, FDA Kansas City District Laboratory, Lenexa, KS

(13) U.S. Food and Drug Administration (1993) *Determination of Arsenic and Selenium by AA Hydride Generation Instrumentation: Perkin Elmer 503/Hydride Generator*, SOP KCM TD E3, FDA Kansas City District Laboratory, Lenexa, KS

(14) U.S. Food and Drug Administration (1995) *Determination of Arsenic and Selenium by AA Hydride Generation Instrumentation: PE 3110/FIAS 400 Hydride Generator*, SOP KCM TD E5, FDA Kansas City District Laboratory, Lenexa, KS

(15) U.S. Food and Drug Administration (1993) *Total Mercury Digestion*, SOP KCM TD M4, FDA Kansas City District Laboratory, Lenexa, KS

(16) U.S. Food and Drug Administration (1993) *Determination of Total Mercury by CVAAS: Perkin Elmer 503/Cold Vapor Generator*, SOP KCM TD E4, FDA Kansas City District Laboratory, Lenexa, KS

(17) Keith, L.H., Crummett, W., Deegan, J., Jr, Libby, R.A., Taylor, J.K., & Wentler, G. (1983) *Anal. Chem.* **53**, 2210–2218

(18) *Measurement of Radionuclides in Foods and the Environment* (1991) IAEA Technical Report Series Pub. No. IDC295, available from UNIPUB, 4611-F Assembly Dr, Lanham, MD 20706-4391

(19) Baratta, E.J. (1994) FAO Food and Nutrition Paper Series14—Manual of Food Quality Control, Part 16—Radionuclides in Food, Food and Agricultural Organization of the United Nations, Rome, Italy

(20) Baratta, E.J., & Reavey, T.C. (1969) *J. Agric. Food Chem.* **17**, 1337–1339

(21) Cunningham, W.C., Capar, S.G., & Anderson, D.L. (1997) *J. AOAC Int.* **80**, 871–882

(22) Anderson, D.L., & Cunningham, W.C. (1995) *J. Radioanal. Nucl. Chem.* **194**, 351–357

(23) U.S. Food and Drug Administration (1999) *FDA Total Diet Study* (INTERNET): www.cfsan.fda.gov/~lrd/pestadd.html

(24) U.S. Food and Drug Administration (June 27, 1995) *Fed. Regist.* **60**, 33106–33109

(25) Dabeka, R.W., & McKenzie, A.D. (1995) *J. AOAC Int.* **78**, 897–909

(26) Pennington, J.A.T., & Jones, J.W. (1987) *J. Am. Diet. Assoc.* **87**, 1644–1650

(27) Pennington, J.A.T., Schoen, S.A., Salmon, G.D., Young, B., Johnson, R.D., & Marts, R.W. (1995) *J. Food Compos. Anal.* **8**, 91–128

(28) Pennington, J.A.T., Schoen, S.A., Salmon, G.D., Young, B., Johnson, R.D., & Marts, R.W. (1995) *J. Food Compos. Anal.* **8**, 129–169

(29) Pennington, J.A.T., Schoen, S.A., Salmon, G.D., Young, B., Johnson, R.D., & Marts, R.W. (1995) *J. Food Compos. Anal.* **8**, 171–217

(30) U.S. Department of Agriculture, Agricultural Research Service (1998) *USDA Nutrient Database for Standard Reference, Release 12*, (INTERNET) Nutrient Data Laboratory Home Page: www.nal.usda.gov/fnic/foodcomp

(31) Souci, S.W., Fachmann, W., & Kraut, H. (1994) *Food Composition and Nutrition Tables*, 5th Ed., CRC Press, Boca Raton, FL

(32) Dabeka, R.W., McKenzie, A.D., Lacroix, G.M.A., Cleroux, C., Bowe, S., Graham, R.A., Conacher, H.B.S., & Verdier, P. (1993) *J. AOAC Int.* **76**, 14–25

(33) Cunningham, W.C., Anderson, D.L., & Baratta, E.J. (1994) *J. AOAC Int.* **77**, 1422–1427

(34) U.S. Food and Drug Administration (August 13, 1998) *Fed. Regist.* **63**, 43402–43403 (INTERNET) Accidental Radioactive Contamination of Human Food and Animal Feeds: www.fda.gov/cdrh/dmqrp/84.html