FSIS 56/04

Uranium-238 in the 2001 Total Diet Study

The Food Standards Agency has completed a survey of uranium-238 in food groups from the 2001 Total Diet Study (TDS). The results provide information on dietary exposures for the average and high rate UK consumer and identify those foods that make a significant contribution to total exposures.

Summary

- Concentrations of uranium-238 are reported for each of the 20 food groups of the TDS. Fish and bread had the highest concentrations of uranium.

- Dietary exposures to uranium-238 for the general UK population and for mean and high level consumers were estimated.

- Cereals and bread were the main source of uranium-238 in the UK diet, contributing up to 65 percent of the total uranium intake for toddlers aged 1.5 to 2.5 years eating above average amounts of food.

- The highest estimated total dietary exposure to uranium-238 was 0.079 micrograms/kilogram of bodyweight/day for toddlers aged 1.5 to 2.5 years eating above average amounts of food. The intake for toddlers is approximately 16 percent of the WHO guideline TDI value of 0.5 micrograms/kilogram of bodyweight /day for the ingestion of soluble uranium. For adults, the total dietary exposure was 0.028 micrograms/kilogram of bodyweight/day (approximately 6 percent of the WHO guideline TDI value).

- There were no health concerns as a result of this study.

Background

Uranium in Food

Uranium occurs naturally in soil at an average concentration of about three parts per million. It is a weakly radioactive element and more than 98 percent of the element exists in the form U-238 and less than 1 percent as the more radioactive isotope U-235, although all the isotopes by definition are chemically identical. Uranium is ubiquitous throughout the natural environment and found in varying amounts in rocks, soils, water, plants, animals and humans. On average, approximately 90 micrograms of uranium exists in the human body from normal intakes of water and food (66 percent in the skeleton, 16 percent in the liver, 8 percent in the kidneys and 10 percent in other tissues). [1]

The primary health risk of uranium arises from its chemical toxicity as a heavy metal and the closest analogy is lead. However, lead has considerably higher toxicity than uranium, since uranium tends to form relatively insoluble compounds which are not readily absorbed into the body. The uranyl ion is the form of mobile uranium within the body. It deposits at bone surfaces and remains in the bone matrix with a half-life of up to one year. It is slowly cleared to the blood and excreted via the kidneys. While in the bone, a very small amount of radiation is emitted but the radiation is very diffuse, so the bone marrow is not effectively irradiated. The uranyl ion does not readily interfere with any major biochemical process except for depositing in the tubules of kidney. Animal experiments have shown that, in heavy doses, uranium can cause damage to kidneys.

Uranium is not readily transferred from soil to crops, and also has a low transfer factor from grass to animals. In addition even when uranium is consumed, only a very small fraction of the element is directly absorbed into the body and about 98 percent is eliminated via the faeces.

This study examined the amount of U-238 in the 20 food groups of the TDS.

The highest concentrations of U-238 were found in fish and bread (**Table 2**). The natural background concentration of uranium in seawater is approximately 260 micrograms/litre and uranium levels in seafood in the Irish Sea range from 0.3 to 0.7 micrograms/kilogram in fish such as cod and 70 to 140 micrograms/kilogram in molluscs such as winkles.

Safety Guideline for Uranium

The World Health Organisation (WHO) has established tolerable daily intakes for uranium [1] that do not result in any significant risk to the health of the consumer over a lifetime of consumption. The tolerable intakes are applicable to long-term exposure of the general public. For insoluble uranium compounds the tolerable daily intake (TDI) is 5 micrograms per kilogram of body weight a day. For soluble uranium compounds, the TDI is 0.5 micrograms per kilogram of body weight a day. For this study, we have used the more conservative TDI for soluble uranium as it is not known whether the uranium in food is in a soluble or insoluble form.

These TDIs apply to the total intake of uranium from all sources including food. Other sources may include drinking or bottled water and inhalation from uranium dusts.

The Total Diet Study (TDS)

The TDS is an important part of the Food Standards Agency's surveillance programme for chemicals in food and has been carried out on a continuous annual basis since 1966. Foods representing the average UK diet are purchased, prepared and combined into food groups. Results from the TDS are used to estimate dietary exposures of the general UK population to chemicals in food, such as nutrients and contaminants, to identify trends in exposure and make assessments on the safety and nutritional quality of food.

The design of the UK Total Diet Study is described in detail elsewhere [2], but in summary involves 119 categories of foods combined into 20 groups of similar foods for analysis. The relative proportion of each food category within a group reflects its importance in the average UK household diet and is based on an average of three previous years of consumption data from the National Food Survey [3-5]. Foods are grouped so that those that may make a significant contribution to dietary exposure (that is, foods known to be susceptible to contamination such as offal and fish, and foods which are consumed in large quantities such as bread, potatoes and milk) are kept separate.

The foods making up the 20 groups are obtained from retail outlets in 24 towns throughout the UK at fortnightly intervals and then transported to one centre where they are prepared.

Each food group obtained from each location (i.e. a total of 480 samples) in the 2001 TDS was mixed to produce a composite UK sample for each food group. The 20 samples were

analysed in duplicate. The mean (average) concentration from the duplicate samples of each food group were used together with data [6-10] on the consumption of these food groups to estimate dietary exposure for adults and toddlers.

Brand names

Brand names are not available as TDS samples are composites of a number of different foods.

Methodology

Sample preparation

Individual components of the TDS food groups were purchased from retail outlets in 24 representative towns in the UK in 2001 and prepared as for consumption, including cooking where appropriate, before being combined into one of 20 food groups. Samples were then thoroughly homogenised and stored at –20 °C until analysis. The 2001 TDS samples were prepared by the Laboratory of the Government Chemist.

Analysis

Samples were analysed in duplicate for uranium at the Central Science Laboratory (CSL). An aliquot (either 0.5g, 1g, 1.5g, 2.5g or 4g depending on water content) of each test sample plus certified reference materials (0.5g) were digested in nitric acid using quartz high pressure closed vessels and microwave heating prior to quantification by inductively coupled plasma-mass spectrometry (ICP-MS). Reagent blanks and a reagent blank spiked with a known amount of analyte were analysed with the test samples for recovery estimate purposes.

Four Certified Reference Materials (CRMs) were used throughout the survey: NIST 1547 peach leaves, NIST 1570 spinach, NIST 1573 tomato leaves and NIST 1575 pine needles. Results for each batch had to be within the certified range, or plus or minus 25 per cent of the quoted value, whichever was greater. See **Table 1**.

Trace Element Analysis Data

All data were corrected for reagent blank and spike recovery. The Limit of Detection (LOD) was calculated from 3 x standard deviation of reagent blank values adjusted for dilution

and sample weight. The Limit of Quantification (LOQ) is 10 x standard deviation of reagent blank values adjusted for dilution and sample weight. Results in **Table 2** given in brackets fall below the LOQ but above the LOD.

Table 1.

Quality Control Data (micrograms/kilogram) uranium-238

CRM		Batch 1	Batch 2	Mean applied
	Percentage Recovery	55	70	
	LOD (1g)	0.106	0.082	0.09
	LOQ (1g)	0.35	0.27	0.31
NIST 1547	Measured value	15	18	
	Certified value	***15***	***15***	
NIST 1570	Measured value	53	43	
	Certified value	46	46	
NIST 1573	Measured value	47	48	
	Certified value	61	61	
NIST 1575	Measured value	21	22	
	Certified value	20	20	

Values in bold and italics are not certified and are provided for information only.

Analytical Results

A summary of the results is given in **Table 2**. Uranium-238 was detected in very low levels in most samples. The highest concentrations were found in the fish and bread groups, both having a mean concentration of 3.5 micrograms/kilogram. The second highest concentrations were seen in meat products.

Mean uranium concentrations in all other food groups were below 2 micrograms/kilogram.

Consumer exposure estimates

The consumer exposure estimates use consumption data taken from the relevant National Diet and Nutritional Surveys [6-10]. Estimates were based on consumers who ate average

amounts of food (mean-level) and those who ate above average amounts of food (high-level) i.e. 97.5th percentile consumers.

Mean and high-level consumer exposures to U-238 were estimated for two ages of toddlers ($1^1/_2$ - $2^1/_2$ year olds and also $3^1/_2$ - $4^1/_2$ year olds) as well as adults. A summary of these exposures is given in **Table 3**. Exposures are expressed as a range from lower bound mean (for those results less than the limit of detection, it has been assumed that concentrations are zero) to upper bound mean (for those results less than the limit of detection). They are expressed on a microgram/kilogram bodyweight basis, which allows for easy comparison with the WHO guideline value.

Exposure estimates for toddlers were higher than those for adults as expected, given their higher food consumption on a bodyweight basis. The food groups contributing the main sources of uranium were miscellaneous cereals, followed by bread and then dairy products. Cereals and bread together contributed up to 65 percent of the total dietary intake for toddlers aged 1.5 to 2.5 years eating above average amounts of food. The highest estimated total dietary exposure to U-238 was 0.079 micrograms/kilogram of bodyweight/day for toddlers aged 1.5 to 2.5 years eating above average amounts of food. This is approximately 16 percent of the WHO guideline value of 0.5 micrograms per kilogram of bodyweight a day.

For adults eating above average amounts of food, the total dietary exposure was 0.028 micrograms/kilogram of bodyweight/day which is approximately 6 percent of the WHO guideline TDI value. The food groups contributing the main sources of uranium were bread and miscellaneous cereals, followed by fish.

Although the consumer exposure estimates in **Table 3** included uranium in beverages, the amount of uranium in the water (either tap water or bottled water) used to make up some of the beverages could vary in different parts of the UK and/or the brand of bottled water. Therefore consumer exposures were also calculated excluding beverages. The consumer exposure estimates were then about 2% lower for both adults and toddlers.

References

1. WHO Media Centre Fact sheet N^o 257 (revised 2003) for Uranium and Depleted Uranium.

2. Peattie, M.E., Buss, D.H., Lindsay, D.G. and Smart, G.Q. Reorganisation of the British Total Diet Study for monitoring food constituents from 1981. Food and Chemical Toxicology, 1983, **21**, 503-507

3. Ministry of Agriculture, Fisheries and Food (1997). National Food Survey 1996. Annual reports of the National Food Survey Committee. The Stationery Office, London.

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6. Gregory, J., Foster, K, Tyler, H and Wiseman, M (1990). Dietary and Nutritional Survey of British Adults. The Stationary Office, London

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9. Gregory, J., Lowe, S., Bates, CJ., Prentice, A., Jackson, LV., Smithers, G., Wenlock, R. & Farron M. (2000). National Diet and Nutrition Survey: Young people aged 4 to 18 years, Volume 1: Report of the diet and nutrition survey, The Stationery Office

10. Gregory, J., Collins, DL., Davies, PSW., Hughes, JM. & Clarke, PC. (1995). National Diet and Nutrition Survey; Children Aged 1½ - 4½ Years. Volume 1: Report of the diet and nutrition survey. HMSO.

Further Information

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Further copies of this Information Sheet can be obtained from:

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A copy of the final report of this survey has been placed in the FSA Library - address detailed above. If you wish to consult a copy, please contact the library for an appointment giving at least 24 hours notice or, alternatively, copies can be obtained from the Library: a charge will be made to cover photocopying and postage.

Table 2. Summary of Uranium-238 concentrations

Food Group	Replicate 1 (microgram/kg)	Replicate 2 (microgram/kg)	Mean (microgram/kg)
Bread	3.9	3.0	3.5
Miscellaneous cereals	2.0	1.6	1.8
Carcass meat	Less than 0.06	Less than 0.06	Less than 0.06
Offal	1.4	1.0	1.2
Meat products	2.6	2.1	2.3
Poultry	0.7	0.4	0.5
Fish	3.9	3.1	3.5
Oils and fats	(0.6)	(0.6)	(0.6)
Eggs	(0.1)	(0.08)	(0.09)
Sugars and preserves	1.3	1.2	1.2
Green vegetables	0.4	0.4	0.4
Potatoes	0.5	0.5	0.5
Other vegetables	0.5	0.4	0.5
Canned vegetables	1.3	1.2	1.2
Fresh fruit	0.1	0.1	0.1
Fruit products	0.3	0.3	0.3
Beverages	(0.04)	(0.04)	(0.04)
Milk	Less than 0.02	(0.03)	(0.02)
Dairy produce	1.6	1.6	1.6
Nuts	0.5	1.0	0.7

Replicates and mean have been rounded to one significant figure.
Where the minimum value is below the LOD this is indicated as ‘Less than’.
Values in brackets fall below LOQ but are above the LOD ie (0.03)

Table 3. Consumer dietary exposures (microgram/kilogram bodyweight/day)

as a result of uranium-238 in food, estimated from the 2001 Total Diet Study

Population Group	Estimated total dietary exposure to uranium-238 (microgram/kilogram bodyweight/day) *	
	Average	High level
Toddlers (1.5 - 2.5 years)	0.043 - 0.044	0.077 – 0.079
Toddlers (3.5 – 4.5 years)	0.039 – 0.041	0.065
Adults	0.015 – 0.016	0.026 – 0.028

*****Exposures to uranium-238 have been estimated from a range (lower – upper bound) of mean concentrations.

1. Consumption data taken from the relevant National Diet and Nutritional Surveys [6-10]