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Observations of Chernobyl Fallout in Imported Food Products

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Abstract

We have tested approximately fifty different imported food products for the presence of radioactivity. Measurable amounts of ^{134}Cs and ^{137}Cs attributable to the Chernobyl nuclear reactor accident were observed in one third of the samples. However, the observed $^{134,137}Cs$ activities are well below established U. S. government safety limits.

Prompted by reports of Chernobyl fallout still appearing in European food products (1-4), we have conducted a small scale survey of imported foods and beverages currently available on the shelves of stores in the San Francisco Bay Area. Approximately fifty different food products from twenty-one different European countries were tested for the presence of gamma-ray emitting radioisotopes. Four American food products were also tested.

A 109-cm^3 high-purity germanium detector was used to search for gamma rays in the energy range from 100 to 2000 keV. Each sample was placed up against the front face of the detector for counting. The samples varied in size from 10 to 500 grams. Approximately 10 cm of lead on all sides provided shielding against room background. Data were accumulated in 4096 channels and were recorded on an IBM PC/AT computer for subsequent analysis. Counting periods for the various samples ranged from 1500 to 500,000 seconds.

Because of the large masses and extended natures of many of the samples tested, determining our effective gamma-ray detection efficiency was somewhat difficult. We attempted to measure these efficiencies as accurately as possible by placing calibrated ($\pm$ 5%) sources of ^{54}Mn, ^{60}Co, and ^{137}Cs at a variety of positions relative to the front face of the germanium detector. In addition, various thicknesses of absorbers were placed between the source and detector in order to mimic the self-absorption of gamma rays within the sample under study. From these measurements, we determined that the absolute photopeak detection efficiency at 662 keV varied from 0.7% to 2.0% depending upon the size, shape, and composition of the sample. The uncertainty in the determination of the counting efficiency is estimated to be $\pm$ 20%.

For most of the products tested, no excess activity above background was observed. However, in approximately one third of the European samples counted, clear gamma-ray lines were observed at 605, 662, and 796 keV. These are known to be the principle lines produced by the decays of ^{134}Cs ($t_{1/2}$ = 2.06 years) and ^{137}Cs ($t_{1/2}$ = 30.2 years) (5). These two long-lived isotopes are known to be responsible for essentially all the remaining contamination from the Chernobyl reactor accident (6). No excess activity above background was observed from any of the American food products tested. Examples of the relevant portions of the gamma-ray spectra obtained in our studies are shown in Figure 1. The results of our measurements are summarized in Table I. The nature of each food product, its country of origin, and the combined ^{134}Cs + ^{137}Cs activity as determined in our measurements is listed. The overall uncertainties in the measured activities are estimated to be $\pm$ 25%.

In order to determine the origin of the observed ^{134}Cs and ^{137}Cs, we compared the measured ratios of the activities of these two isotopes with that observed from the fallout deposited in western Europe soon after the Chernobyl accident. Because of their very different half-lives but similar fission yields, the $^{137}Cs/^{134}Cs$ activity ratio is indicative of the age of the fuel element in which they were produced. This age, of course, varies from reactor to reactor. Thus, the $^{137}Cs/^{134}Cs$ ratio is a " fingerprint " of the particular reactor that released them. In all but one of the food samples in which we observed cesium activity, the $^{137}Cs/^{134}Cs$ activity ratio was (as of October, 1987) 2.95 $\pm$ 0.30. When extrapolated back to the date of the Chernobyl accident (April 25, 1986) this ratio becomes 1.88 $\pm$ 0.19, which agrees very well with the value of 1.85 derived from measurements of the prompt fallout (6). This shows that the $^{134,137}Cs$ activity we observed had its origin in the Chernobyl reactor.

The sample of Italian dried mushrooms showed a $^{137}Cs/^{134}Cs$ activity ratio that was substantially larger than that observed from any other food product. As mentioned above, this ratio depends upon the age of the fuel element in which these cesium isotopes were produced. While it is known that that average age of the fuel elements in the Chernobyl reactor was about 600 days (6), there undoubtedly were fuel elements with a variety of ages. Older elements would have relatively more ^{137}Cs than ^{134}Cs in them. Thus, if there were incomplete mixing of material from different fuel elements, then some variation in the $^{137}Cs/^{134}Cs$ activity ratio in the fallout would be expected. What fell on these Italian mushrooms may have been from this incompletely mixed material.

In response to the Chernobyl accident, the U. S. government reduced the maximum permissible combined ^{134}Cs + ^{137}Cs activities in food products from 75 pico-Curies/gram to 10 pico-Curies/gram (7). Both of these cesium isotopes have biological half-lives of 70 days (8). This means that if a person consumed a total of 2 kg/day of foods and beverages all of which were contaminated with this level of activity, then at equilibrium one would have a body burden of 0.5 micro-Curies of ^{134}Cs and 1.5 micro-Curies of ^{137}Cs. These levels are well below the maximum permissible body burdens of 2.0 micro-Curies and 3.0 micro-Curies for ^{134}Cs and ^{137}Cs, respectively, established for non-radiation workers (8).

As one can see from Table I, in the imported food products which showed detectable amouts of radioactivity, the levels of ^{134}Cs + ^{137}Cs we observed ranged from 0.1 to 5 pico-Curies/gram. These levels are well below the ceilings set by the U. S. government. We also tested samples of thyme and bay leaves that are currently being sold in stores in the south of France and found combined ^{134}Cs + ^{137}Cs activity levels near this 10 pico-Curie/gram ceiling.

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TABLE I. Combined $^{134}Cs + ^{137}Cs$ activities observed in the present study . Uncertainties in the measured activities are estimated to be ± 25%. n/d indicates that no activity was detected. Detection limits varied among samples from 0.02 to 0.1 pico-Curies/gram. All food samples were obtained from San Francisco Bay Area retail stores.

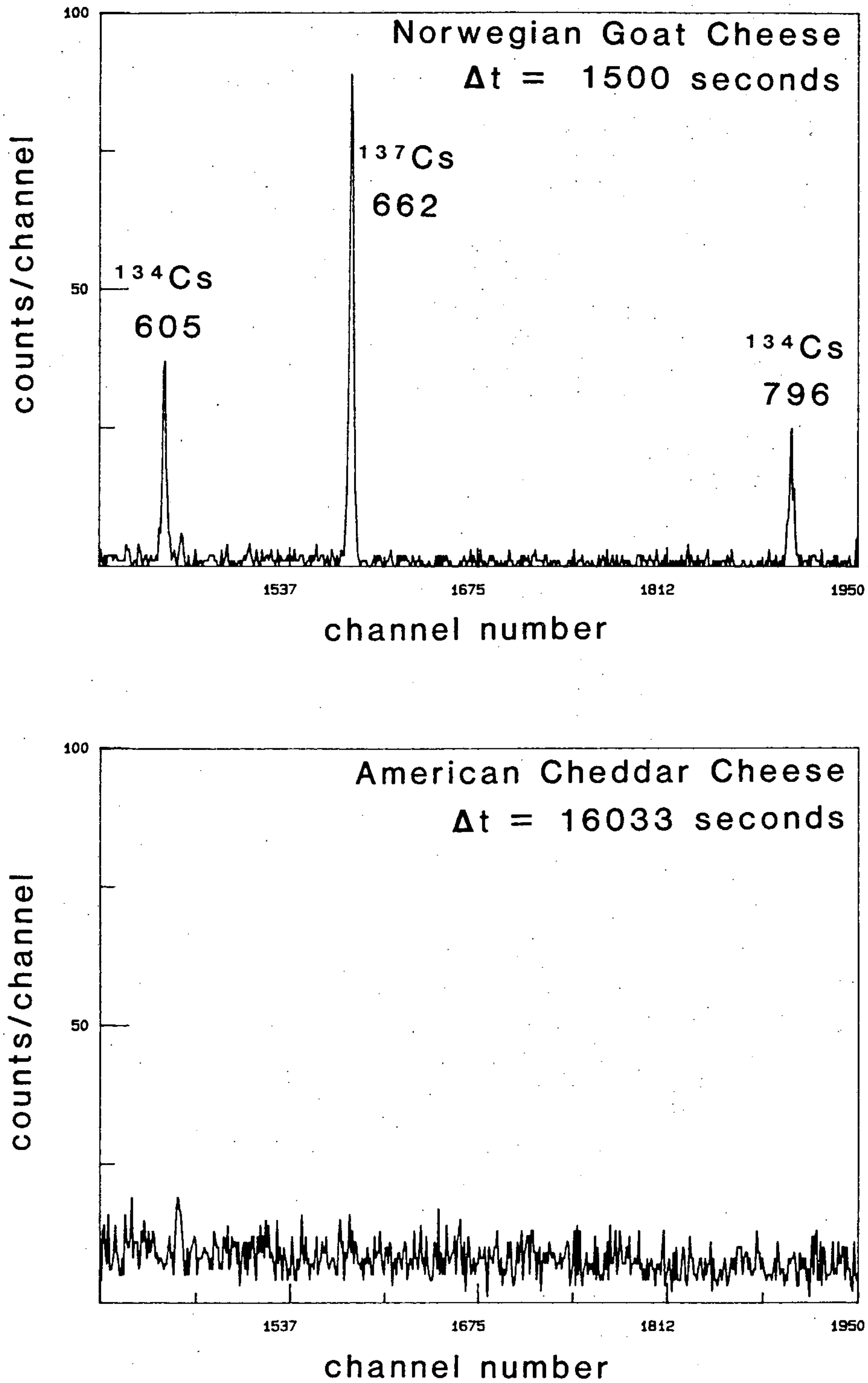
Country of Origin	Product	$^{134}Cs + ^{137}Cs$ Activity (pCi/g)
England	beer	n/d
	crackers	n/d
Belguim	beer	n/d
	shallots	n/d
Spain	white wine (1986)	n/d
France	red wine (1986)	n/d
	white wine (1986)	n/d
	black olives	n/d
	raspberry jam	n/d
	apricot jam	n/d
	honey (1986)	0.4
	goat cheese	0.2
	rouquefort cheese	0.2
Italy	pasta (brand 1)	n/d
	pasta (brand 2)	1.3
	pasta (brand 3)	0.8
	pasta (brand 4)	1.6
	olive oil	n/d
	red wine (1986)	n/d
	white wine (1986)	n/d
	dried mushrooms	4
Switzerland	green cheese w/herbs	0.2
	emmenthaler cheese	0.13
Austria	blackberry jam	0.4
	beer	n/d
West Germany	cheese w/herbs	n/d
	soft cheese	n/d
	beer	n/d
	gummi bear candy	n/d

TABLE I. (continued)

The Netherlands	beer	n/d
Denmark	ham	n/d
	blue cheese	n/d
Norway	beer	n/d
	goat cheese	5
Sweden	lingon berry sauce	0.13
	crispbread	n/d
Finland	rye crackers	0.16
U. S. S. R.	vodka	n/d
Czechoslovakia	beer	n/d
Poland	ham	n/d
Hungary	paprika	n/d
Roumania	feta cheese	n/d
Bulgaria	feta cheese	1.4
Yugoslavia	beer	0.1
Greece	black olives	n/d
	beer	1.4
U. S. A.	beer	n/d
	pasta	n/d
	cream cheese	n/d
	cheddar cheese	n/d

Figure Caption

Figure 1. Top panel shows a portion of the gamma-ray spectrum observed from 25 minutes of counting a 104-gram sample of Norwegian goat cheese. Lower panel shows the same region of the spectrum observed from 267 minutes of counting a 198-gram sample of American cheddar cheese. The gamma-ray lines that appear in the upper spectrum are labeled by their energy in keV and by the radioisotope that produces them.



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