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CESIUM-134 AND CESIUM-137 IN HONEY BEES AND CHEESE SAMPLES COLLECTED IN THE U.S. AFTER THE CHERNOBYL ACCIDENT

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ABSTRACT

As a result of the Chernobyl accident on April 25, 1986, possible radioactive contamination of honey bees and cheese sampled in several areas of the United States were measured. Of bees collected in May and June of 1986 in both Oregon and New York, only those from Oregon showed detectable levels of cesium-134 ($T_{1/2}$ = 2.05 years), a radionuclide which would have originated from the Chernobyl incident. Cheese produced in Oregon and New York before the accident showed only cesium-137 ($T_{1/2}$ = 30.23 years) but cheese produced afterwards (May and September, 1986) in Oregon contained cesium-134. Cheese produced in Ohio and California at the time of the accident and thereafter contained only cesium-137. In general, the levels of radioactivity were higher in the West coast samples as compared to those taken in the East. The levels of radioactivity detected were considered to be toxicologically of no consequence.

INTRODUCTION

The extent of radioactive contamination in Europe and the meteorological factors which affected it shortly after the Chernobyl accident on April 25, 1986 have been described (Persson et al. 1987; Hohenemser et al. 1986). Transport of radioactive material to England (Hamilton et al. 1986) and Canada (Joshi 1987) have also been reported following the incident.

In the present investigation, it was of interest to study the pattern of radioactive contamination in biological samples in the United States that would represent concentration of radioactive fallout. Honey bees and cheese were chosen as such indicators of contamination because bees contact innumerable foliar and other surfaces during foraging and cheese represents a concentrated dairy by-product after cattle graze relatively large pasture areas or consume considerable hay, silage, freshly cut forage or harvested grain. Honey bees have been used in the past as biological indicators of environmental radioactivity (Hakonson and Bostick 1976).

Hamilton et al. (1986) and Pringle et al. (1986) have reported that cesium-134 and cesium-137 are two of the radionuclides that were released by the Chernobyl reactor. The presence of cesium-134 ($T_{1/2}$ = 2.05 years) in such environmental samples collected in May through August of 1986 is a good indication that the source of radioactive contamination resulted from the Chernobyl accident. Cesium-137 ($T_{1/2}$ = 30.23 years) contamination could have resulted from the Chernobyl incident or from much earlier above-ground nuclear testing (Simpson et al. 1977; Bird 1968). In this study these two radionuclides were measured in the honey bee and cheese samples.

EXPERIMENTAL

Honey bees from hives and cheddar cheese samples made from locally-produced milk were obtained from Oregon, California, Ohio and New York during the period between April and August of 1986. Cesium-134 and cesium-137 were determined in the samples by direct gamma spectrometry of samples contained in a 250 ml or 1 liter Marinelli beaker using a HPGe detector and a computer based multichannel analyzer. All analyses of duplicate samples (of which there were five) and recount samples (of which there were four) were in agreement within ± two standard deviations and were thus considered to be reasonably homogeneous as collected.

RESULTS AND DISCUSSION

The dates and locations of sampling and radionuclide concentrations found are given for the honey bees in Table 1 and the cheese in Table 2. Considering the honey bees collected in May and June (post Chernobyl) in both Oregon and New York only those from Oregon showed detectable levels of cesium-134 which would have originated from the Chernobyl incident. Cheese produced before the accident in Oregon and New York showed only cesium-137 but that produced afterwards (May and September, 1986) in Oregon contained cesium-134. Cheese produced at the time of the accident and thereafter in Ohio and California contained only cesium-137. The ratio of cesium-137 to cesium-134 in the bee and cheese samples that contained both radionuclides ranged from about 2 to 3. In general, the levels of radioactivity were higher in the west coast samples of bees and cheese as compared to those taken in the East. The Environmental Protection Agency reported higher concentrations of these two radionuclides in air samples in May in California and Nevada than at the same time in Pennsylvania.

It is very difficult to precisely predict the ultimate magnitude and extent of global radionuclide contamination following an atmospheric atomic test or a nuclear accident such as that at Chernobyl. Radionuclides such as Cs-137 are presumably ejected at the site of such accidents as particles or become attached very early to aerosols and grow by coagulation with other particles during transport (Jost et al. 1986). Rainfall plays a dominant role in the deposition of radioactive particles (Joshi 1982). It has also been reported that the concentration in rainwater of radionuclides such as strontium-90 show a marked seasonal variation with peaks in the late spring and troughs in the late fall. This is now generally believed due to a maximum rate of transfer of material from the stratosphere to the

Table 1. Cesium-134 and cesium-137 in honey bees sampled in Oregon and New York in 1986

Collection date (1986)	Oregon[a] Radionuclide	Oregon[a] Concentration[c] (pCi/g ± 1 sigma)	New York[b] Radionuclide	New York[b] Concentration[c] (pCi/g ± 1 sigma)
May 1	Cs-137	0.050 ± 0.020	Cs-137	nd[d]
May 5	Cs-137	0.031 ± 0.025	Cs-137	nd
May 9	Cs-137	0.016 ± 0.024	Cs-137	0.018 ± 0.020
May 13			Cs-137	0.066 ± 0.034
May 14	Cs-137	0.081 ± 0.024		
May 17	Cs-137	0.101 ± 0.024	Cs-137	0.067 ± 0.024
May 21	Cs-137	0.054 ± 0.028	Cs-137	0.046 ± 0.021
May 25	Cs-134	0.034 ± 0.013	Cs-137	0.039 ± 0.021
	Cs-137	0.072 ± 0.023		
May 29	Cs-134	0.051 ± 0.013	Cs-137	0.047 ± 0.030
	Cs-137	0.084 ± 0.021		
June 2	Cs-134	0.083 ± 0.018	Cs-137	0.023 ± 0.022
	Cs-137	0.065 ± 0.023		
June 6	Cs-137	0.013 ± 0.033	Cs-137	0.094 ± 0.040
June 10	Cs-137	0.053 ± 0.033	Cs-137	0.029 ± 0.028
June 14	Cs-137	0.079 ± 0.021	Cs-137	0.046 ± 0.018
June 18	Cs-134	0.033 ± 0.016	Cs-137	0.052 ± 0.021
	Cs-137	0.102 ± 0.023		
June 22	Cs-134	0.034 ± 0.014	Cs-137	0.040 ± 0.021
	Cs-137	0.067 ± 0.021		
June 26			Cs-137	0.016 ± 0.017

[a]Tillamook County
[b]Tompkins County
[c]Picocuries per gram, fresh weight basis
[d]Not detectable

troposphere during the spring (Holloway 1979). Mechanisms for the deposition of submicron particles carrying significant amounts of radioactivity onto foliar surfaces and physicochemical aspects of the retention, uptake and desorbability of such particles is not well understood (Joshi 1982).

Contamination of honey bees and cheese by radionuclides presumably relates back to foliar contamination. A study of cesium-137 contamination of squash and bean plants showed that about 65% of the contamination could be removed by washing thus indicating surficial residues. Also, the magnitude of contamination sharply diminished on foliar surfaces more than 20 cm above the soil surface (White et al. 1981). Cesium-137 uptake by smart weed (Polygonum lapathifolium) was reported to be greater if soil potassium was low (Graham 1958), indicating competitive root uptake by the two elements. A study of spacial variability of

Table 2. Cesium-134 and cesium-137 in cheese sampled in Oregon, California, Ohio and New York in 1986

Collection date (1986)	Radio-nuclide	Concentration[a] (pCi/g ± 1 sigma)
	Oregon[b]	
April 2	Cs-137	0.0102 ± 0.0030
May 3	Cs-134	0.0126 ± 0.0026
	Cs-137	0.0238 ± 0.0032
September[c]	Cs-134	0.0122 ± 0.0023
	Cs-137	0.0301 ± 0.0029
	California[d]	
January 26	Cs-137	0.0094 ± 0.0141
April 28	Cs-137	0.0073 ± 0.0118
	Ohio[e]	
April	Cs-137	nd[f]
May	Cs-137	0.022 ± 0.013
June	Cs-137	nd
July	Cs-137	nd
August	Cs-137	0.014 ± 0.014
	New York[g]	
April 13	Cs-137	nd
July 10	Cs-137	nd

[a]picocuries per gram, fresh weight basis
[b]Benton County
[c]Precise date unknown
[d]Solano County
[e]Stark County
[f]Not detectable
[g]Tompkins County

fallout cesium-137 in the soil of a cultivated field in Germany showed it to be random and confined to the upper plow layer (A horizon) of the soil profile (Bachhuber et al. 1987). A model for predicting the contamination of food products by cesium-137 following its deposition to ground was described by Jackson et al. (1987). Good agreement was found between predicted contamination and the results from analytical field monitoring. The order of decreasing contamination was cereals and fruits > leafy green vegetables > root vegetables. The bran of cereals has been reported to contain more cesium-137 than the flour (Jackson et al. 1987; Bunzl and Kracke 1987).

Contamination of lichens by cesium-137 and the resulting animal food chains including caribou, wolves, reindeer and man is well known (Hanson 1968; Knight and Bartal 1987) and farm animals consuming such radionuclides in their feeds can likewise transfer these to the resultant meat or dairy by-products. The United States Food and Drug Administration has

stated that a level of 75 picocuries per gram of imported meat or poultry for cesium-134 or cesium-137 cannot be exceeded if the products are to be marketed in this country (Radionuclide levels, 1986). The levels of these radionuclides found in cheese in this study would therefore not appear to constitute a toxicologic hazard to consumers. Whether bees contaminated by cesium radionuclides would result in their transfer to the honey is not known.

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