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Radioactivity of Honeybee Honey

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Of the various types of radiation, the high energy α-emitter can cause great damage because of its high ionizing capability. Luckily, its large size prevents deep penetration into tissues. Those radionuclides that are the most destructive are those that can penetrate the soft tissue and become part of active metabolism. Cesium-137 has these noxious properties. Its chemical similarity to potassium means that it is rapidly adsorbed by the bloodstream and can be distiributed in all cells of the body. Its half-life is 27 years (Miller Jones 1993). Radioactive cesium in the environment is mainly the effect after the nuclear accident at Chernobyl on April 26, 1986. Not long after the discovery of ionizing radiation clinical evidence, mainly effects on the skin, indicated that ionizing radiation is harmful to human tissues and enhances the risk of cancer and congenital defects (Jankowski 1995). The cumulation of Cs-137 in the fauna and flora of freshwater basins is essential for food contamination (Zalewski 1996). Additionally doses of ionizing radiation descend from natural radionuclides, of which the most important is potassium K-40. There have been many investigations on the content of radionuclides in food (Kubik 1996; Grabowski 1994; Mazur 1993; See1 1995). We don't however have much information on cesium and potassium contamination measurement in honeybee honey, which are a natural component of our diet. Honey is a liquid (or semiliquid) product made up of about 80% solids. It contains a complex mixture of carbohydrates, namely, fructose (25 - 45%), glucose (25 -37%), maltose (2 -12%) and sucrose (0.5 - 3%) with traces of many other sugars depending on the floral source (Clarke 1995). The mean content of mineral substances in honey has been calculated to be 0.17% (White 1979). The purpose of the present study was to measure the average cesium-137 and potassium-40 levels in honeybee honey 12 years following the Chernobyl accident,

MATERIALS AND METHODS

The honey samples were counted by gamma- spectometry using coaxial germanium detector with a 15% efficiency and the computer system Canberra S - 100 for the collection and analysis of spectra. The detector was contained in a 10 cm thick lead , container internally lined with two sheets of aluminium and copper. All the samples were measured for the period of 80000 s.

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- According to the size of the samples two kinds of measurement vessels were used:
- volume 80 cm^3, cylindrically shaped, 2 cm high and 7.5 cm in diameter.

When we began our study we supposed that twelve years after the Chernobyl accident radioactivity of honey samples might be lower than the low limits of detection (LLD) by gamma spectrometry. The preliminary results of our work support this supposition (Zalewski 1995). Therefore we thoroughly analysed the lower limit of detection (LLD) of the measurement set used. The analysis was made according to Currie's method (Currie 1968). The lower limit of detection in this method is given by the equation

$$LLD = 2.71 + 4.65\delta \qquad \text{for 95\% confidence limit}$$

where: δ - standard deviation of the background in the peak interval.

The activity limit A_d is given by the equation

$$A_d = LLD\ C/\varepsilon\ p\ \Delta t$$

where: $C = \Delta t\ \lambda / [\ 1 - \exp(-\lambda\ \Delta t)]$; Δt - measurement time; λ - decay constant; ε - counting efficiency for gamma ray considered; p – photon emission probability.

For specific activity estimation, the minimal detectable concentration (MIX) is

$$MDC = A_d/m$$

where: m – mass of the sample.

The samples of honey measured in a 80 cm^3 vessel had MDC = 0.5 Bq/kg for Cs-137.

RESULTS AND DISCUSSION

In the honey samples, the concentration of Cs-137 ranged from 0.5 to 46.3 Bq/kg. The highest content of Cs-137 was in heather honeys - mean 24.3 Bq/kg (Table 1). There was significant association between the concentrations of Cs-137 in the heather honeys and other kinds of honey ($p<0.05$). Also other authors (Bunzl 1988; Adriano 1981) having found that the deposition of radionuclides in soils from forests was ninefold higher than in neighbour grassland and arable land.

Mellin and Wallberg (1991) reported that after the Chernobyl accident the trees in firtree forests absorbed about 90% of radionuclides from the fallout, and leafy trees below 35%. Our investigations showed that Cs-137 content was significantly higher in conifer honeydew honeys than leaf-tree honeydew honeys ($p<0.05$).
The lowest average value of cesium was found in flower honey - 0.6 Bq/kg. The Department of Radiology Protection survey (Jednoróg 1991) showed that Cs- 137 content in honeys from the Warsaw environs after the Chernobyl accident in 1986 was 25.3 Bq/kg, but decreased in 1989 to below 0.3 Bq/kg. Honey samples were also examined by Bonazzola and Ropolo (Bonazzola 1991) in the Piedmontese localities during the spring-summer period of 1987. In the honey from high mountain multifloral the concentration of Cs-137 was 1.3 Bq/kg. The mean

Table 1. Mean content of Cs-137 and K-40 in honey.

Honey Type	Number of Samples	Cs-137 content (Bq/kg) Min-max	Mean Cs-137 content (Bq/kg)	K-40 content (Bq/kg) Min-max	Mean K-40 content (Bq/kg)
Acacia honey	6	0.5-2.1	0.8	36.5-102.3	55.8
Buckwheat honey	7	0.5-11.7	2.8	43.9-492.1	**122.7**
Lime honey	5	0.5-2.2	0.8	51.8-74.2	64.4
Rape honey	4	0.5-0.9	0.6	40.1-89.3	55.4
Heather honey	6	2.4-46.3	**24.3**	53.3-77.0	64.1
Flower honey	5	0.5-0.8	0.6	20.5-63.0	39.1
Conifer honeydew honey	3	5.4-6.5	6.0	41.9-181.4	**132.9**
Leaf-tree honeydew honey	3	0.7-1.3	1.0	123.8-134.5	**130.4**
Total: 39		**Mean: 4.6 ± 8.2**		**Mean: 83.1 ± 38.6**	

content of Cs-137 in our investigations (1997,1998) was higher - 4.6 Bq/kg.

The mean content of K-40 in our samples was 83.1 Bq/kg. The highest content of K-40 was determined in honeydew honeys - mean 131.7 Bq/kg. In nectar honeys the highest content of K-40 was found in buckwheat honeys - mean 122.7 Bq/kg (Table 1). The lowest average value of potassium was determined in flower honey - 39.1 Bq/kg. The average content of K-40 in honey from the Warsaw environs in 1989 was 22.0 Bq/kg (Jednoróg 1991) and in the Piedmontese localities in 1987 was 23.6 Bq/kg (Bonazolla 1991).

According to the World Health Organization and International Atomic Energy Agency, the admissible level of Cs-137 in food is 1000 Bq/kg (WHO 1995; IAEA 1994). In Poland, the Annual Limit of Intake (ALI) for cesium 137 is 80000 Bq and for potassium 40 - 200000 Bq (Law Gazette 1988). The daily consumption of 47 kg of tested honey causes exceeding AL1 for Cs-137 but 6.5 kg for K-40.

The level of these radionuclides is far below those assumed as safe in food products by the international commissions of radiological protection.

REFERENCES

Adriano DC, Hoyt G.D, Pinder III JE (198 1) Fallout of Cesium- 137 on a forest ecosystem in the vicinity of a nuclear fuel reproccesing plant. Health Phys 40: 369

Bonazolla GC, Ropolo R (1991) Distribution of fallout radionuclides in soil, plants, and honey. Health Phys 4: 575-577

Bunzl K, Kracke W (1988) Cumulative deposition of Cesium-137, Plutonium-238, Plutonium-239, Plutonium-240 and Americium-241 from global fallout in soils from forest, grassland and arable land in Bavaria, West Germany. J Environ Radioact 8: 1

Clarke M A (1995) Bulk sweeteners. Encyclopedia of Analytical Science; Townshend A, Ed.; Academic Press: London 9: 5091

Currie L A (1968) Limits of qualitative detection and quantitative determination. Anal Chem 40: 586-593

Grabowski D, Muszynski W, Petrykowska M, Rubel B, Smagala G, Lada W (1994) Activity of cesium-134 and cesium- 137 in game and mushrooms in Poland. Sci Total Environ 157: 227

International Atomic Energy Agency (1994) International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources. Safety Series No. 115-1, IAEA, Vienna

International Atomic Energy Agency (1994) Intervention Criteria in a Nuclear or Radiation Emergency. Safety Series No. 115-I, IAEA, Vienna

Jankowski J (1995) Health risk assessment in exposure to ionizing radiation. Polish J Med Phys Eng 3: 13-18

Jednoróg S, Mazur G (1991) Radioactivity of honeys. Medycyna Weterynaryjna 47: 282

Kubik M, Michalczuk L, Dzieciol U (1996) Contamination of fruits in Poland after the Chernobyl accident. Scientific Symposium Chernobyl 1986-1996:

47-52
Law Gazette (1988) Zarzadzenie Prezesa Panstwowej Agencji Atomistyki w sprawie dawek granicznych promieniowania jonizujacego i wskazników pochodnych okreslajacych zagrozenie promieniowaniem jonizujacym Monitor Polski 14: 124
Mazur G, Jednoróg S (1993) Radioactive Food Contamination in Warsaw in the Fifth Year After the Chernobyl Accident. Polish J Food Nutr Scien 2: 87-91
Melin J, Wallberg L (1991) Distribution and retention of cesium in Swedish Boreal forest ecosystems, w: The Chernobyl fallout in Sweden, Results from a research programme on environmental radiology. The Swedish Radiation Protection Project. Arprint. Lund & Stockholm : 467
Miller Jones (1993) Food Safety, Eagan Press, St. Paul, USA
Seel J F, Whicker F W, Adriano D C (1995) Uptake of 137 Cs in Vegetable Crops Grown on a Contaminated Lakebed. Health Phys 68: 793-799
White JW (1979) Jr. Composition of honey. Comprehensive Survey of Honey, Crane E, Ed.;Heinemann: London Chapter 5
World Health Organization (1995) Manual on Public Health Action in Radiation Emergencies. European Centre for Environmental and Health, Rome Division
Zalewski M Kapala J, Tomczak M, Mnich Z (1995) Cs-137 contamination of lake sediment in North -East Poland. Przeglad Geologiczny 43: 656-659
Zalewski M, Mnich Z, Kapala J, Tomczak M (1996) Radiocaesium in the Sawinda Wielka Lake ecosystem 9 years after the Chernobyl accident. Polish Arch Hydrobiol 43: 455-463