RESULTS OF RADIOACTIVITY MEASUREMENTS ON FOODSTUFFS IN ROMANIA

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INTRODUCTION

The radionuclides presence in foodstuffs is due both to the natural radioactivity and to the radioactive pollution from different sources.
The main radionuclides from foodstuffs are:
a. Potassium - 40 (^{40}K), which has a great natural abundance, because it represents 0.0118% from the entire potassium in nature, indicator of the natural radioactivity of foodstuffs.
b. Some of the natural radionuclides, the decay products of uranium and thorium, have a minor contribution of foodstuffs' radioactivity but are very dangerous for human being and this is the reason why these radionuclides are regularly analysed.
c. The artificial radionuclides: radiocaesium (^{134}Cs, ^{137}Cs) with metabolization relatively similar to potassium, radioiodine (principally ^{131}I) with metabolization quite identical with iodine, radiostrontium (principally ^{90}Sr) with metabolization relatively similar to calcium, and ^{239} Pu with reduced metabolization, which is not specific.
The permanent monitoring of foodstuffs' radioactivity allows the assessment of the radiological risk and of the food ingestion contribution to the Effective Dose Equivalent (EDE) (1).

MATERIALS AND METHODS

The foodstuffs are sampled recurrently from representative areas like: Bucharest, Bechet (affected by Kozloduj NPP, Bulgaria), Cernavoda (future NPP), middle of the Transilvania, Neamt (a mountainous area in Moldavia).

The samples consisted in: milk and dairy products, meat and meat products, fish, wheat flour, fresh fruits and vegetables.

The radioactivity measurements are performed by high-resolution low-level gamma-ray spectrometry.

Between 1986-1989 the samples were measured both directly and prepared (by drying and ashing). After 1989 the samples were prepared for measuring by

standard procedures (2,3,4Č. The samples measured directly were disposed in MARINELLI beakers of 0.5; 1.0; 1.5 and 3.0 litters. The ashed samples were disposed in plastic cylindrical boxes of 0.15 l.

The measurements were carried out from 2-24 hours, using a 4096 channels MCA Canberra S 85 with a coaxial closed-end HPGe detector.

Energy and efficiency calibrations were done through special calibration procedures, using certified reference materials from IAEA-Vienna or RPC-INPE Bucharest, in the same geometries and at the same densities like the samples.

There are identified and analysed mainly: ^{134}Cs, ^{137}Cs, ^{40}K and ^{131}I.

The statistical confidence level of measurements was 2 σ and the measurements were performed according to the general rules of ISO 9000 standards and GLP.

RESULTS AND DISCUSSION

The ^{134}Cs, ^{137}Cs amounts for the considered foodstuffs and areas are presented as extreme mean values in Table 1.

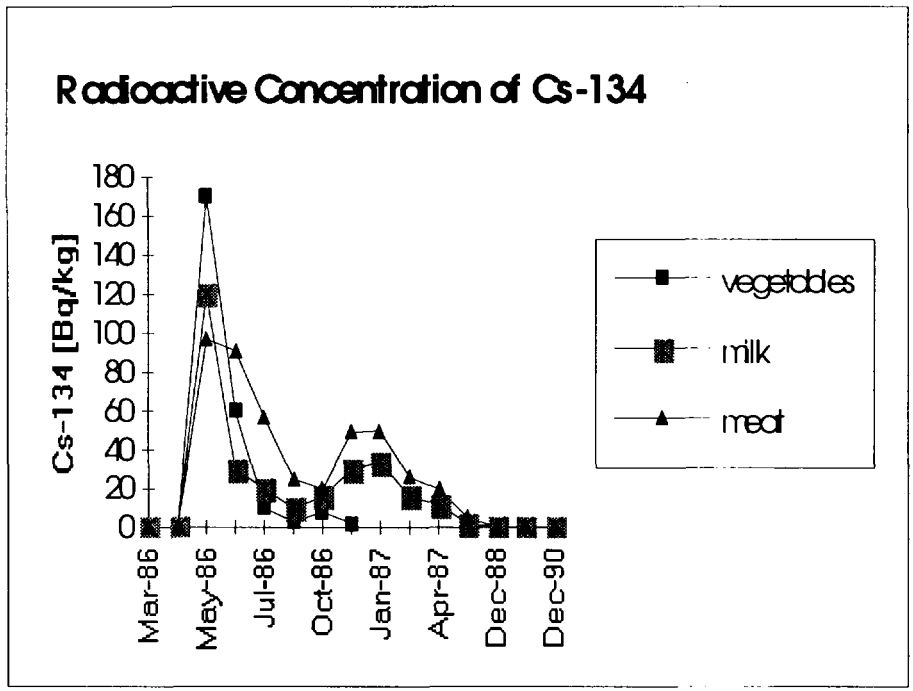
After the Chernobyl accident there are pointed out the drastic increasing of radioactive concentrations. Although they are not shown in the Table, in May 1986 there were recorded some results over 1000 Bq/kg (for example cheese Bucharest and sheep milk, 1274Bq/kg, respectively 2587 Bq/l of ^{137}Cs). The caesium levels were decreased with an exponential form (Figure 1). For milk, dairy products, meat and meat products there is an increase in the winter period of 1986-1987. This fact is explicable by contaminated feeds. The seasonal variations in the radiocaesium contents are connected with the change of the forage (5) The vegetal samples present, after 1987, small amounts of caesium due the specific transfer processes in environment (6).

For the radioiodine concentrations, presented in Figure 2, the exponential decreasing in May and June is more significantly with the maximum occurring between May 6-10. After July, radioiodine was not more detected.

In May-June there were also measured: ^{95}Nb in vegetables, fruits, grass, fish and beef, between 1.2 -210.0 Bq/kg; ^{103}Ru (2.7-1310.0 Bq/kg) in vegetables fruits wheat, fish, milk and pork; ^{141}Ce (2.6-141.5 Bq/kg) in vegetables, fruits and milk; ^{144}Ce (4.6-66.6 Bq/kg) in grass, wheat, vegetables and fruits; ^{132}Te (only in May, 9.6-1014.0 Bq/kg and 4.9-51.5 Bq/l) in vegetables, fruits, respectively in cow milk and sheep milk; ^{95}Zr (2.6-10.7 Bq/kg) in vegetables grass, wheat and fish; and $^{140}Ba/^{140}La$ in vegetables and fruits between 12.0/53.7-728.0/1751.4 Bq/kg and in cow milk and sheep milk between 3.3/22.8-124.7/310.2 Bq/l, but which was not more identified after the first week of June. The vegetables consist, mainly, on spinach and salad, and the analysed fruits were strawberries and cherries.

There were also observed, especially in the first period after May 1986, many and large variations in activity concentrations. The local and meteorological conditions explain these variations.

Figure 1


Radioactive Concentration of Cs-134
Cs-134 [Bq/kg]
180
160
140
120
100
80
60
40
20
0
Mar-86
May-86
Jul-86
Oct-86
Jan-87
Apr-87
Dec-88
Dec-90
vegetables
milk
meat

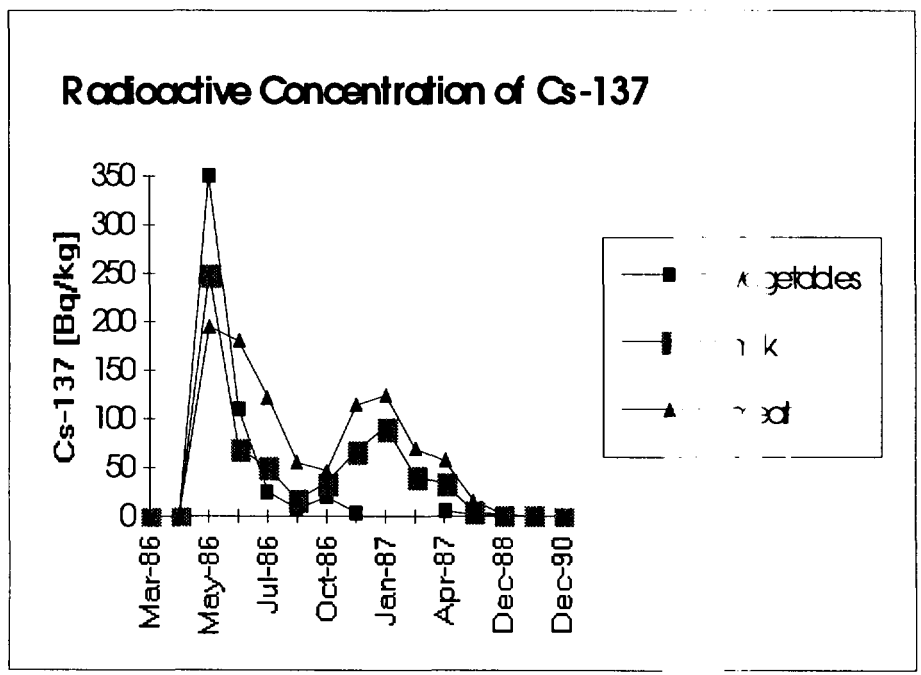

Radioactive Concentration of Cs-137
Cs-137 [Bq/kg]
350
300
250
200
150
100
50
0
Mar-86
May-86
Jul-86
Oct-86
Jan-87
Apr-87
Dec-88
Dec-90

Table 2 Radioactive Concentrations of ^{40}K in Foodstuffs between 1986-1995, in Bq/kg(l)

No	Sample	Extreme mean values
1	Milk	38-60
2	Dairy products	30-46
3	Beef	83-130
4	Pork	72-118
5	Meat products	50-78
6	Fish	85-138
7	Wheat Flour	45-80
8	Vegetables	35-180
9	Fruits	30-90

Figure 2

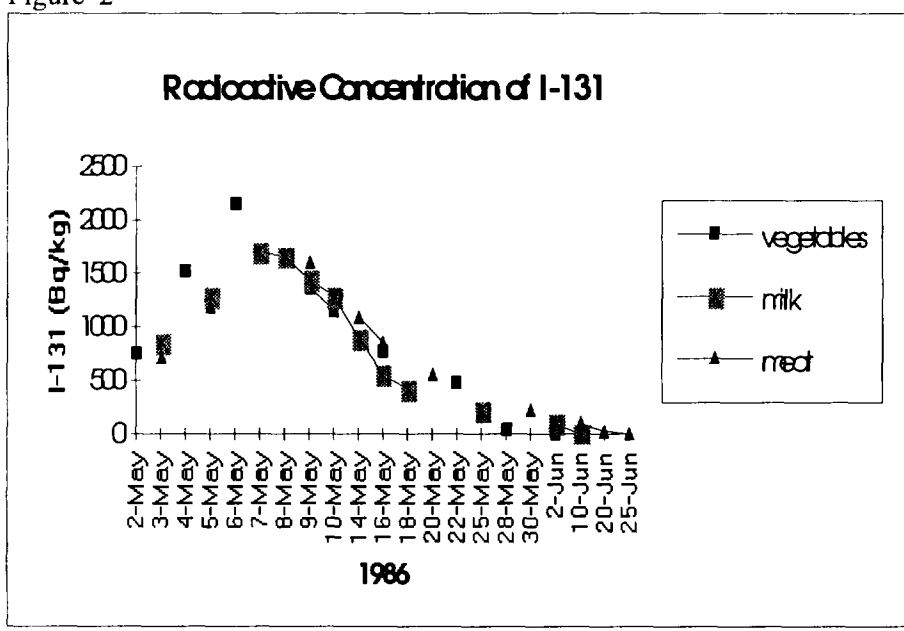


Table 1 Radioactive Concentrations of Caesium in Foodstuffs between 1986-1995, in Bq/kg[l] (extreme mean values)

	Radio-nuclide	1986 1st term	1986 May	1986 June	1986 3rd term	1986 4th term	1987 1st term	1987 the rest	1988	1989	1990	1991-1995
Milk	Cs-134	<0.1	79-120	20-30	8-20	16-30	16-34	1.7-11.8	0.4-1.2	0.3-0.5	<0.1	<0.05
	Cs-137	<0.1	181-250	40-70	17-50	35-67	42-92	5.4-33.5	1.5-4.2	0.5-1.0	0.1-0.4	0.08-0.2
Dairy products	Cs-134	<0.1	131-632	60-92	16-45	26-48	19.9-48.6 58-121.1	2.9-17.6	0.7-2.6	0.5-0.6	0.1-0.6	<0.05
	Cs-137	<0.1	208-1274	120-215	28-102	62-104		9.2-48.5	2.8-10.1	0.5-2.4	0.2-0.9	<0.1
Beef	Cs-134	<0.1	51-125	35-110	22-60	15-62	29-68	5-18.5	0.3-2.7	0.2-2.1	0.2-0.6	0.2-0.5*
	Cs-137	<0.1	109-255	60-209	43-125	33-145	80-163	16-51	1.5-9.5	0.5-6	0.2-0.9	0.2-1
Pork	Cs-134	<0.1	35-69	34-72	28-54	25-36	23-32	5-22	0.4-3.1	0.3-1	0.2-0.4	<0.1
	Cs-137	<0.1	70-135	85-150	66-120	60-83	59-85	15-63	2-10	0.4-1.8	0.2-0.8	0.2-0.8
Meat products	Cs-134	<0.1	35-90	25-70	8-25	4.5-13	15-25.8	4-12	0.3-2.3	0.2-1.5	0.1-0.5	0.1-0.5*
	Cs-137	<0.1	71-182	53-140	15-45	11-30	40.2-64.7	13.5-33	1.5-8	1.0-4.2	0.1-0.7	0.5-1
Fish	Cs-134	<0.1	5-13.6	5-14	1-4.3	1.6-2	1-1.4	0.6-1.1	0.2-0.8	<0.2	-	-
	Cs-137	<0.1	9-25	9.2-26	2.5-9.6	3.2-4.5	2.3-3.4	1.9-3	0.7-2.4	<0.3	-	-
Wheat Flour	Cs-134	<0.1	-	52-55	35	-	16-27.9	2.7-15	0.3-2.2	0.1-0.5	<0.1	-
	Cs-137	<0.1	-	110-125	75	-	40-72.1	8.4-33	1.1-7.8	0.1-1	0.1-0.4	-
Vege-tables	Cs-134	<0.1	100-170	25-60	3-10	2.3-8	-	0.5-2.2	0.2-0.4	<0.2	0.1-0.5	<0.1
	Cs-137	<0.1	210-350	50-110	8-25	4-20	-	1.6-5.8	0.4-1.5	0.2-0.4	0.1-1	0.2-0.3
Fruits	Cs-134	<0.1	12-30	10-25	3-19	2.8-3.2	-	0.7-4.6	0.2-0.5	<0.2	<0.2	<0.1
	Cs-137	<0.1	25-60	20-50	8-45	6.5-8.8	-	2.3-12.7	0.9-1.9	<0.4	0.1-0.7	<0.1-0.3

*in 1993 some samples of - beef: Cs-134: 1
Cs-137: 17
- meat products: Cs-134: 0.5
Cs-137: 11.5

After 1989 the radioactive amounts in foodstuffs were quite similar to the amount measured before 1986.

The ^{40}K amounts for the considered foodstuffs and areas are presented as extreme mean values in Table 2, ascertaining the constancy of radioactive concentrations.

Immediately after the Chernobyl accident an Expert Consultation on Recommended Limits for Radionuclide Contamination of Foods was convened at FAO Headquarters, Rome, 1-5 December 1986.

The consultations adopted "Interim International Radionuclide Action Levels for Food" (7).

In 1989 WHO adopted in Codex Alimentarius (8) the levels for radionuclides in food moving in international trade following accidental contamination.

Comparing our results with these levels, we notice that, from 1988 all foodstuffs' samples are in compliance with these maximum permitted values.

CONCLUSION

After the Chernobyl accident, the caesium and other artificial radionuclides amounts present a drastic increasing, but the ^{40}K (natural) amounts do not vary.

After 1988 all foodstuffs' samples are in compliance with the maximum permitted levels of radioactive contamination of foodstuffs following a nuclear accident [7,8].

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EXTENDED SUMMARY

There are presented the results of gamma-spectrometric measurements performed between 1986-1995 on: milk and dairy products; meat and meat products; fish; wheat flour; fresh fruits and vegetables.

The foodstuffs are sampled from some representative areas like: Bucharest, Bechet (affected by Kozloduj NPP, Bulgaria), Cernavoda, middle of Transilvania, Neamt.

The radioactivity measurements are performed by high-resolution γ-ray spectrometry.

There are identified and analysed mainly ^{134}Cs, ^{137}Cs, ^{40}K and, sometimes, other radionuclides.

There are pointed out: the constancy of natural radionuclides amounts; the drastic increasing in radioactive concentration in May 1986; the seasonal variation of radioactivity in some food items; the time - exponential diminution of radioactivity in 1991-1995; and the maximum permitted levels of radioactive contamination of foodstuffs following a nuclear accident.