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# GAMMA CONTAMINATION FOOD FACTORS FOR MILK POWDER AND WHEY

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*Partial gamma contamination food factors for I-131, Cs-134, Cs-137 and Ru-106 and total gamma contamination food factor for milk powder, whey and some confectionery products (chocolate, chocolate creme and baby food) contaminated after the nuclear accident at Chernobyl were calculated. The samples were imported from different European countries immediately after the accident, in 1986 and in 1987. The activity of the radionuclides was determined on a Ge(Li) detector by standard gamma spectrometry.*

*The permissible level (600 Bg/kg) of the radionuclide content in food at that time is discussed considering the total activity of the samples and the quantities in which milk powder and whey are used in the diet, as well as in confectionery and animal feed production.*

*Key words: food, feed, radioactive contamination, gamma spectrometry*

## INTRODUCTION

Milk powder and dried whey are both important foodstuffs of animal origin, especially in diets for children, confectionery production and as significant additives in the production of concentrate mixtures for domestic animals. They show certain advantages compared to fresh milk as the dry matter left after the removal of water seems to be a rather unsuitable environment for microorganisms. Not less important are advantages in storage, preservation and transportation (Milosavljević, and Puhac, 1988).

Before the nuclear accident at Chernobyl in April 1986, dose limits for whole body or specific organs or tissues were the subject of recommendations of numerous international organizations (International Commission for Radiation Protection, World Health Organization, United Nations Committee for Atomic Radiation) but little consideration was given to systematic and regulated control of the radioactive contamination of foodstuffs in international trade. Immediately after the accident at the Chernobyl nuclear plant, different countries applied different "action levels" for radionuclide content in imported foods, even using different terms: "levels of concern" (United States of America), "screening limits"

(Canada). "maximum permitted levels" (European Community) etc. It was only in December, 1986 that the "International Radionuclide Action Levels for Food" taking into account target organs, dose levels and annual radionuclide and food intake, were recommended by the Food and Agriculture Organization (FAO) experts at their Meeting in Rome (RAO Report, 1986).

After the Chernobyl accident, milk powder and whey were classified as highly contaminated foodstuffs in most countries (UNCEAR Publ., 1988). The activity of the long lived Cs-137 in milk powder imported into our country in 1987. exceeded one hundred Bq/kg whereas in diets for children its activity ranged from 2-18 Bq/kg (Vertacnik et al., 1988). Moreover; it should be noted that in confectionery production milk powder and whey contribute from 20-50% of the total mass of the final product and in animal feed production even less: from 5-10% as additives and from 2-30% as liquid or solid fodder substitutes. In the diet they are diluted in the ratio 1:8. With all that in mind, the permissible level of 600 Bg/kg adopted in most European countries after the Chernobyl accident should be seriously guestioned (IAEA Safety Series 75, 1986).

We have calculated the partial gamma contamination food factors for I-131, Cs-134, Cs-137 and Ru-106 and the total gamma contamination food factors for milk powder, whey and some confectioneries as immediate indicators for increased radioactivity in food and fodder, especially in large scale nuclear accidents. These factors take the activity of K-40 as a "natural" reference of radiocontamination in food as it is in a relatively narrow and well established range and is easy to be evaluated spectroscopically (Gonzales, and Anderer, 1989; Kukoc et al., 1992).

## MATERIAL AND METHODS

Samples of milk powder, whey, chocolate, chocolate creme and baby food from different European countries (France, former Czechoslovakia, Holland, former Yugoslavia, Poland) produced immediately after the nuclear accident at Chernobyl in May 1986, later during 1986 and in 1987 were obtained.

The activity of natural K-40 and fission radionuclides: short lived I-131 (8,04 d), comparatively short lived Cs-134 (2,06 y) and Ru-106 (368 d), and long lived Cs-137 (30 y) in fresh, homogenized samples of food was determined on a Ge(Li) detector (relative efficiency 23%, ORTEC) and a 4096 channel analyzer (Nuclear Data ND-100).

Calibration was performed with a point etalon source of Eu-152 (EGMA3, France) for the energy range of 121. 78-1403.08 keV. Geometric efficiency (200 g PVC cylinder) was determined by a secondary standard for solid state matrices (Djuric et al., 1986).

The counting time was 4,000-40,000 s due to the total activity of the sample. The total average error of the method was 20%

## RESULTS AND DISCUSSION

The activity of natural K-40 and the fission radionuclides I-131, Cs-134, 137 and Ru-106 in milk powder, whey, chocolate, chocolate creme and baby food measured in 1986 and 1987 are presented in Tables 1, 2, 3 and 4.

The values presented are the means of the activities measured in the investigated samples. The variations in the activity levels found for I-131, Cs-134, 137 and Ru-106 were from 30-50%, due to the country the samples were imported from, the year of sampling and the radionuclide examined. For variations greater than 100%, the maximum activity level ("<") was presented. K-40 activity variations were below 10% due to different producers, except for baby food, where was about 20%.

The activity of three other comparatively short lived radionuclides: Ce-144 (284 d), Sb-125 (3,77 y) and Rh-102 (206 d) were estimated, too, but their total activity was rather low: <20 Bq/kg in 1986 and <5 Bq/kg in 1987 for milk powder and whey, and <1Bq/kg for confectioneries and baby food in 1987. Therefore, they were excluded from the calculations of partial and total gamma contamination food factors.

Table 1. Activity (Bq/kg) of K-40 in milk powder, dried whey and some confectioneries

| Year | Milk powder | Whey | Chocolate | Choc. creme | Baby food |
|---|---|---|---|---|---|
| 1987 | 497 | 611 | 125 | 96 | 231 |

Table 2. Activity (Bq/kg) of radionuclides in milk powder

| Year | Country | I – 131 | Cs – 134 | Cs – 137 | Ru – 106 |
|---|---|---|---|---|---|
| | France | 10.6 | — | 3.7 | 28 |
| 1986 | Yugoslavia | 152 | 557 | 1290 | 232 |
| | CSSR | — | 74 | 188 | < 20 |
| 1987 | Holland | — | 5.3 | 14 | — |
| | Poland | — | 261 | 644 | 28 |

Table 3. Activity (Bg/kg) of radionuclides in whey

| Year | Country | Cs – 134 | Cs – 137 | Ru – 106 |
|---|---|---|---|---|
| 1987 | Yugoslavia | 249 | 731 | < 32 |

Table 4. Activity (Bg/kg) of radionuclides in confectioneries

| Year | Food | Country | Cs – 134 | Cs – 137 | Ru – 106 |
|---|---|---|---|---|---|
| | Chocolate | Austria | 69 | 200 | < 45 |
| 1987 | Choc. creme | Yugoslavia | 29 | 90 | < 19 |
| | Baby food | Yugoslavia | 11 | 29 | < 4 |

The partial gamma contamination food factors (PGCFF) defined as the ratio of the activity of the specific radionuclide and the activity of natural K-40 in the sample were evaluated and the results are presented in Tables 5,6 and 7.The toatal gamma contamination food factor (TGCFF) as the sum of the partial factors was calculated, too.

Table 5. Gamma contamination food factors in milk powder

| | | P G C F F | | | | |
|---|---|---|---|---|---|---|
| Year | Country | I – 131 | Cs – 134 | Cs – 137 | Ru – 106 | TGCFF |
| | France | 0.02 | — | 0.01 | 0.06 | 0.09 |
| 1986 | Yugoslavia | 0.31 | 1.12 | 2.60 | 0.47 | 4.50 |
| | CSSR | — | 0.15 | 0.38 | 0.04 | 0.57 |
| 1987 | Holland | — | 0.01 | 0.03 | — | 0.04 |
| | Poland | — | 0.53 | 1.30 | 0.06 | 1.89 |

Table 6. Gamma contamination food factors in whey

| | | P G C F F | | | |
|---|---|---|---|---|---|
| Year | Country | Cs – 134 | Cs – 137 | Ru – 106 | TGCFF |
| 1987 | Yugoslavia | 0.41 | 1.20 | 0.05 | 1.66 |

Table 7. Gamma contamination food factors in confectioneries

| | | | P G C F F | | | |
|---|---|---|---|---|---|---|
| Year | Food | Country | Cs – 134 | Cs – 137 | Ru – 106 | TGCFF |
| | Chocolate | Austria | 0.55 | 1.60 | 0.40 | 2.55 |
| 1987 | Choc. creme | Yugoslavia | 0.30 | 0.94 | 0.20 | 1.44 |
| | Baby food | Yugoslavia | 0.05 | 0.13 | 0.02 | 0.20 |

As can be seen from the data presented in Tables 1-4, the highly non-uniform contamination of the environment due to the Chernobyl accident in 1986 (Djuric et al., 1989) resulted in a very broad activity range for radionuclides in foods produced and imported from different European countries.

Some of the food exceeded the International Radionuclide Action Levels adopted by the European Community (EC) and Food and Agricultural Organization (FAO): 600 Bq/kg immediately after the accident, 350/kg and 500 Bq/kg for Cs-134 and Cs-137 respectively, for the first year after the accident and 50 Bq/kg and 100 Bq/kg, respectively for the following years. Consequently, some samples of milk powder in 1986 and 1987, and some samples of whey and chocolate in 1987 could have been considered contaminated.

However if one considers the partial and total gamma contamination food factors, the situation seems quite different. From the data presented in Tables 5-7, except for some samples of milk powder immediately after the accident (TGCFF>6), both gamma contamination food factors indicate excessive radioactivity only by a factor of 1-2, for a specific radionuclide or for the activity as a whole. Taking into account the dilution of milk powder or whey in human nutrition or the percentage in which they are used as additives in animal feed, and the quantities of confectioneries consumed daily, the factors are smaller by nearly an order of magnitude and definitely < 1.

It can therefore be concluded that milk powder and whey when used mainly as raw materials and additives in food and fodder production did not present a significant source of radiocontamination for the consumers of final products. However, for workers involved in storage, production processes and transportation, dealing with large amounts of milk powder and whey, the situation could be different (Petrovic et al., 1989). They could be regarded as a critical group in radioactive contamination due to a large scale accident. Therefore, the radionuclide action levels in food should be considered and adopted for each category of food and feed taking into account numerous factors, and not only the absolute level of activity.

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## FAKTORI RADIOAKTIVNE KONTAMINACIJE ZA MLEKO U PRAHU I SURUTKU

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SADRŽAJ

Izračunati su parcijalni i ukupni faktori kontaminacije za mleko u prahu, surutku i neke konditorske proizvode (čokolada, čokoladni kremovi, dečija hrana) kontaminirane u toku i neposredno posle nuklearne nesreće u Černobilu, 1986. godine. To je osnova za razmatranje usvojenih dozvoljivih nivoa sadržaja radionuklida u hrani i hranivima obzirom na ukupni sadržaj radionuklida i količinu u kojoj se pojedine vrste hraniva konzumiraju u ishrani i proizvodnji prehrambenih proizvoda.