The Removal of Radionuclides from Foodstuffs During Technological Treatment and Culinary Processing

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Abstract. Comparative data on the efficiency of industrial and domestic processing techniques of plant and animal products, which reduce radionuclides content foodstuffs, are summarized. Methods, which provide the greatest decrease of radionuclides content in the final products with minimum losses of nutritional value, were identified.

Agricultural production in the Ukraine is conducted on the territories, where soils contamination does not exceed 555 kBq/m^2. However, in the western regions of Ukraine, the Rovno region in particular, where up to 40-50 % of the soil cover are peaty soils with high transfer of Cs^{137} to agricultural crops (10-100 times higher than on mineral soils), these limitations are up to 1-5 Ci/m^2 = 3.700 - 17.500 kBq/m^2. Besides, a lot of cattle in private sector (2-3 cows per family) are determined by the lack of good pastures, and forest and swampy pastures are used, where transfer factors are the highest (100-200 times higher). In these regions the greatest contribution of foodstuffs to internal irradiation dose is observed.

At low doses of external irradiation, reduction of internal dose by agricultural products processing (reduction of Cs specific activity in the products, consumed by population) can significantly improve the radiological situation in the region and reduce social tension.

Analysis of the contribution of separate human diet components to the total intake of radiocaesium by the human organism, demonstrates that 70-85 % of radiocaesium is transferred with animal products (milk, meat). Therefore it is necessary to apply measures for the reduction of radiocaesium intake with these products.

Radioprotective measures on all stages of food chains allow to reduce considerably the radionuclides content in the final products. In the experimental conditions one can achieve decontamination of foodstuffs by a factor ten, but in industrial conditions countermeasures efficiency is much lower to a factor 2-4..

For the reduction of radiocaesium content in foodstuffs, produced from milk and meat, there are enough simple and practicable methods, thus, with milk processing to fresh cheese the specific radioactivity decreases 1.3-1.4 times, at producing sour cream with 20, 30 and 40 % fat content - by 1.2, 1.4 and 1.6 times respectively, at cheese-making-up to 8 times, at processing to butter - 5 and more times.

Presently in the collective sector, due to the complex of radioprotective measures, one managed to reduce radiocaesium content in animal products below intervention levels. In the private sector the situation is different. In two villages of Dubrovitsa district, Rovno region, we analyzed per example the diets of inhabitants and radiocaesium intake with foodstuffs. The diet of village inhabitants consists mainly of foodstuffs, produced on private plots. Each inhabitant on his private plot is producing a limited range of foodstuffs, most of which is consumed by the family.

Specific radioactivity of cheese samples and samples of sour cream with 30 % fat content, produced in domestic conditions, was, on the average, about 1.4 times lower than the specific radioactivity in the milk. This reduction is in proportion to the reduction of the milk water phase in dairy products, where radiocaesium is concentrated. In order to reduce radiocaesium transfer with dairy products, produced and consumed by local population, we recommend to process milk to such foodstuffs, the technology of which provides a significant reduction of Cs^{137} transfer from milk to ready product.

The specific activity of Cs^{137} in cheeses prepared by standard methods was found to be between 1.3 and 5 times lower than the specific activity of the milk from which they were prepared. Under all conditions the conversion of milk to cheese results in the cheese retaining less than 8 % of the total Cs^{137} activity of the original milk. The specific activity of Sr^{90} in cheeses whose coagulation pH was greater than 5.5, was found to be between 5 and 10 times greater than the specific activity of the milk from which they were prepared. However, the specific activity of Sr^{90} in quark, an acid cheese (coagulation pH approx. 2), was 1.5 times lower than the specific activity of the initial milk. This is consistent with the binding characteristics of the Sr^{90} protein complex. Acidification of the milk to pH of 5.1 (the isoelectric point of this protein) or less results in a liberation of most alkaline ions from the proteins into the aqueous phase. At coagulation pH values greater than 5.1 between 50 and 70 % of the total Sr^{90} activity of the original milk remains in the cheese, whereas at a coagulation pH of 4.39 this amount is reduced to 8 %.

Nutritional analysis of the cheeses showed that the nutritional content of cheeses produced by modified techniques did not differ significantly from those produced by standard techniques.

Within the project framework, the effect of technological processing and culinary preparation of meat for the reduction of radionuclides content was investigated.

Optimum conditions for the removal of radiocaesium from contaminated meat were determined, which include the effect of the following parameters: the size of meat pieces treated, the meat type, the treatment type, the brine-to-meat ratio, the NaCl concentration, the treatment temperature, the effect of the pH of the treatment solution.

The experiments demonstrated that for salting of meat an additional one hour treatment will result in approximately 60 % decontamination. These treatment conditions will achieve maximum decontamination while minimizing losses of nutrients. If greater decontamination is required, the treatment time may be increased or the meat size decreased. Such modifications will, however, result in increased losses of water soluble nutrients.

Among different domestic meat cooking methods boiling, stewing and frying was investigated. The work was done with meat of bull, fed in 10 km ChNPP zone. Meat radioactivity was about 30000 Bq/kg.

The results obtained testify that boiling is the most effective method for radiocaesium removal from meat (Fr = 0.13 - 0.14). Besides, additional salting accelerates the process of radiocaesium transfer to broth. Less than a half of the initial activity was found in stewed meat (Fr = 0.4). However, extracted juice at this method of culinary preparation is usually consumed with meat, while in the first case it is not used. At frying Fr value was 0.77-0.80, as both meat and fat are used for food. Deep freezing of meat does not influence radiocaesium migration in the course of meat culinary preparation.

Together with milk human diets include plant products - potatoes, vegetables, which are not themselves dangerous from the point of view of Cs accumulation, but taking into account that in the diet of rural inhabitants potatoes consumption is 200-300 kg per year, and that of cabbage 50-100 kg, it is necessary to consider the contribution of these products to the dose. Due to the peculiarities of living and eating habits in many contaminated districts, the people are picking up and eating traditional forest products - mushrooms and berries, which accumulate a lot of caesium, and, therefore, should be taken into account as well.

Complex agrochemical decontamination measures for the reduction of radionuclides transfer to animal products is not always practicable and effective enough..

A considerable reduction of radionuclides transfer to foodstuffs is provided by technological processing and culinary preparation. It is reasonable to start the processing of raw foodstuffs from mechanical cleaning of their surface from soil.

The effects of various culinary and preservation techniques, such as mechanical processing, cooking, canning, marinating and brining, on the radiocaesium content of these food types are evaluated. Those techniques resulting in the greatest reduction of the radiocaesium content of the final product were identified.

At salting of vegetables and mushrooms, the amount of radiocaesium consumed with these products will be 1.5 - 2 times less than in the initial product, if the brine is not going to be used for food (sauerkraut, salted cucumbers, mushrooms).

The most effective method of culinary plant products preparation is thermal processing, which allows to reduce radiocaesium content (from 2 to 10 times) (boiling of potatoes, mushrooms).

An essential reduction can be obtained also by soaking dry and fresh mushrooms and berries in water (1.5 - 3 times) for 30 - 35 hours.

Consequently, the above-mentioned technologies allow to considerably reduce the caesium content in foodstuffs consumed by people, living on contaminated territories, thus decreasing internal irradiation dose.