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Results of Radiation Assessment of the Content of Cesium-137 and Strontium-90 in Food Products in the Kakheti Region, Georgia

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Abstract

The aim of the study was to determine the spectrum of radionuclides, namely the content of cesium and strontium, in local food products in the Kakheti region (Telavi, Gurjaani and Lagodekhi municipalities) of Georgia, and its hygienic assessment.

A sampling of food products was carried out from 4-5 places. The weight of the combined sample of meat products was 1 kilogram, as was the weight of the sample of vegetables, and the sample of dairy products was 600 grams. A sampling of food products was carried out in meat-processing plants, markets, and shops.

Qualitative and quantitative identification of radionuclides in the taken samples was performed in the Laboratory of the Ministry of Agriculture of Georgia (identification code No. F-003-2016-G).

Fifteen locally produced staples (from peasant farms) that are most commonly consumed by the local population were studied in the Kakheti region.

Comparing the results of the study carried out to identify radionuclides in food products with the permissible specific activity of radionuclides, it can be seen that the content of radionuclides in local food products in the Kakheti region is much lower than allowed by radiation safety standards. According to the results of the study, it can be assumed that the internal dose of radiation of the population conditioned by 137Cs and 90Sr would be relatively low. Though this fact does not give a reason for calm. To obtain a complete picture of internal doses of radiation, it is necessary to continue research with the aim of qualitative and quantitative identification of radionuclides in local and imported food products, as well as to study the actual nutrition of the population.

Keywords: radiation, radionuclides, radioactivity, assessment, Cs-137, Sr-90.

Introduction

The population of the earth is constantly affected by the radiation background, which is created by the radiation of cosmic rays, natural radionuclides that existed on the earth and radionuclides obtained artificially as a result of human activities. This effect on living organisms is manifested in the internal and external doses of radiation, which can become dangerous to human health.

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The source of internal radiation is the food, water, air consumed by a man, or radionuclides through a wound.

Radionuclides of terrestrial origin, entering the body, cause its internal radiation, which is created by ^{40}K, ^{14}C, ^{226}Ra, ^{210}Po, ^{3}H, ^{87}Rb, ^{90}Sr, ^{137}Cs, and isotopes of other elements.

The radiation dose depends on the quantitative and the qualitative composition of radionuclides, their chemical form, and state of aggregation, on the routes (oral, inhalation, and through the skin) and the rate of entering the body and the duration of action. Peculiarities of the deposition of radionuclides in vital organs, the routes, and rate of their excretion from the body, as well as other factors, affect the formation of the radiation dose [1-2].

^{137}Cs is an active isotope of cesium, which is one of the main components that radioactively pollute the biosphere. It is a beta and gamma emitter, is included in radioactive emissions, as well as in the radioactive waste of those plants that process remains of nuclear power plants. It is found in organisms of plants, humans, and animals. The accumulation coefficient of ^{137}Cs is relatively high in freshwater algae and flora of the Arctic land; it also accumulates in mushrooms. In animal organisms, it accumulates in muscles and the liver. The highest accumulation coefficient in animals is found in the north deer and North American waterbirds. The ^{90}Sr isotope is a radioactive substance with a half-life of 28.9 years. It is a beta emitter. It takes hundreds of years for it to completely decay once released into the environment. It is released into the environment during a nuclear explosion. It is also produced in nuclear reactors during their operation [3].

Radioactive strontium almost always has a negative effect on the human body. Accumulating in bone tissue, it irradiates the bone marrow, which increases the risk of bone marrow cancer and leukemias; when accumulated in the body in large quantities, it can cause the development of acute radiation sickness [4, 5, 6].

Objectives

The objectives of the research was to determine the spectrum of radionuclides, namely the content of cesium and strontium, in local food products in the Kakheti region (Telavi, Gurjaani, and Lagodekhi municipalities) of Georgia, and its hygienic assessment.

Methods

The most active deposition of ^{137}Cs and ^{90}Sr in the soil occurs in a layer with a depth of 1 to 5 cm. In view of the above, we mainly investigated products that come in contact with this particular level.

A sampling of food products was carried out from 4-5 places. The weight of the combined sample of meat products was 1 kilogram, as was the weight of the sample of vegetables, and the sample of dairy products was 600 grams. A sampling of food products was carried out in meat-processing plants, markets, and shops.

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Qualitative and quantitative identification of radionuclides in the taken samples was performed in the Laboratory of the Ministry of Agriculture of Georgia (identification code No. F-003-2016-G) using multichannel alpha-, gamma-spectrometer analyzer (of Canbera Company).

Fifteen locally produced staples (from peasant farms) that are most commonly consumed by the local population were studied in the Kakheti region.

The results were processed using the SPSS 25.

Results

The research results showed that the specific activity of the radionuclide ^{137}Cs in meat and meat products is very low. The specific activity of beef was 0,08±1,32 Bq/kg, which is 0,05% of its permissible amount, and that of chicken meat was 0,5% of its permissible amount, that is, 0,76±1,69 Bq/kg (Table No. 1). The data are statistically reliable ($p < 0.05$).

Table No. 1
Specific activity of ^{137}Cs in meat and meat products

Product name	Specific activity Bq/kg	Permissible activity of ^{137}Cs, Bq/kg
Beef	0,08±1,32	160
Chicken meat	0,76±1,69	160

The radionuclide ^{90}Sr was found in meat and meat products in trace amounts, presumably indicating that locally produced meat and meat products are free of strontium-90. Although the data are statistically unreliable ($p>0,05$) (Table No. 2).

Table No. 2
Specific activity of ^{90}Sr in meat and meat products

Product name	Specific activity Bq/kg	Permissible activity of ^{90}Sr, Bq/kg
Beef	0,00±10,2	50
Chicken meat	0,00±11,90	50

A radionuclide study of dairy products showed that the specific activity of ^{137}Cs in the cheese composition is 0,96±1,55 Bq/kg, and in the case of cottage cheese - 0.97 Bq/kg. The maximum permissible level of ^{137}Cs in dairy products is 50 Bq/kg. The results of our research suggest that local milk and dairy products are not dangerous in terms of creating high doses of internal radiation, and these data are statistically reliable ($p<0, 05$) (Table No. 3). As for strontium, it was found in dairy products in trace amounts (Table N 4).

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Table No. 3
Specific activity of ^{137}Cs in dairy products

Product name	Specific activity, Bq/kg	Permissible activity of ^{137}Cs, Bq/kg
Cheese	0,96±1,55	50
Cottage cheese	0,97±1,61	50

Table No. 4
Specific activity of ^{90}Sr in dairy products

Product name	Specific activity, Bq/kg	Permissible activity of ^{90}Sr, Bq/kg
Cheese	0,00±11,1	100
Cottage cheese	0,00±11,7	100

The specific activity of radionuclides was determined on fruits and vegetables sampled in various municipalities of the Kakheti region, which are products of daily consumption. Samples were taken in the spring. Thus, seasonal fruits - cherry plum and strawberry - were selected for analysis.

As a result of studying the radionuclide activity of fruits, it was found that the activity of cesium-137 in strawberry is 1,01±1,71 Bq/kg, and in cherry plum - 2,58±2,07 Bq/kg. The data obtained are below the permissible activity of ^{137}Cs for strawberry by 39.6 times, and for cherry plum - by 15.5 times (Table No. 5).

Table N 5
Specific activity of ^{137}Cs in seasonal fruits

Product name	Specific activity, Bq/kg	Permissible activity of ^{137}Cs, Bq/kg
Strawberry	1,01±1,71	40
Plum	2,58±2,07	40

In the compositions of strawberries and cherry plums, strontium was found in trace amounts, which indicates that these seasonal fruits are not contaminated with radionuclides and are environmentally friendly (Table No. 6).

Table No. 6
Specific activity of ^{90}Sr in seasonal fruits

Product name	Specific activity, Bq/kg	Permissible activity of ^{90}Sr, Bq/kg
Strawberry	0,00±12,30	50
Plum	0,00±12,80	50

For the study of melons and vegetables, the most frequently consumed products were selected - cabbage, cucumber, tomato, pepper, greens, and potato, which are in direct contact with the soil, form and grow there.

In general, the specific activity of the radionuclide cesium-137 in melons and vegetables is quite low, though its relatively high activity was recorded in bell pepper and cucumber (2,91±2,29 and 1,97±2,07 Bq/kg, respectively), which is 1,51 % of the permissible level for cucumber and 2,23 % for bell pepper.

Among the vegetables we studied, the specific activity of cesium-137 turned out to be the lowest in potato - 0,8 Bq/kg, in which the permissible level of this radionuclide is 320 Bq/kg (Table No. 7).

Table No. 7
Specific activity of ^{137}Cs in vegetables and melons

Product name	Specific activity, Bq/kg	Permissible activity of ^{137}Cs, Bq/kg
Greens	1,68±3,79	130
Bell pepper	2,91±2,29	130
Tomato	1,01±1,46	130
Cucumber	1,97±2,07	130
Cabbage	1,61±2,24	130
Potato	0,86±2,21	320

A small amount of strontium-90 in the same vegetables and melons were found only in greens (1,90±16,70 Bq/kg) and tomato (1,10±10,90 Bq/kg), for which the maximum permissible level of strontium-90 is 50 Bq/kg.
The specific activity of strontium-90 was comparatively high in cabbage - 2,2 Bq/kg, which is 4,4 % of the permissible level. In the study of bell pepper, cucumber, and potato, strontium was found in trace amounts (Table No. 8).

Table N 8
Specific activity of ^{90}Sr in melons and vegetables

Product name	Specific activity, Bq/kg	Permissible activity of ^{90}Sr, Bq/kg
Greens	1,90±16,70	50
Bell pepper	0,00±13,20	50
Tomato	1,10±10,90	50
Cucumber	0,00±13,20	50
Cabbage	2,20±13,00	50
Potato	0,00±11,20	60

As a result of radionuclide identification of cereals, the same pattern was revealed as in the study of other products. Namely, the specific activity of cesium-137 and strontium-90 is far below the permissible level.
The specific activity of ^{137}Cs turned out to be relatively high in maize grain - 2,15±1,62 Bq/kg, and the lowest - in the wheat grain - 1,27±1,41 Bq/kg, which is 37.2 times lower than the permissible level in the case of maize grain and 63 times in the case of wheat grain (Table No. 9).

Table No. 9
Specific activity of ^{137}Cs in grain products

Product name	Specific activity, Bq/kg	Permissible activity of ^{137}Cs, Bq/kg
Wheat grain	1,27±1,41	80
Maize grain	2,15±1,62	80
Bean	1,57±2,33	130

The relatively high specific activity of ^{90}Sr was revealed in wheat grain - 11,30±11,40 Bq/kg, though this amount does not exceed the twelfth part of the permissible level (Table No. 10).

Table #10
Specific activity of ^{90}Sr in grain products

Product name	Specific activity, Bq/kg	Permissible activity of ^{90}Sr, Bq/kg
Wheat grain	11,30±11,40	140
Maize grain	0,00±11,30	140
Bean	0.00±13.40	50

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The results of the research showed that local food products in the Kakheti region contain the radionuclides (^{137}Cs and ^{90}Sr) studied by us in small amounts and are environmentally friendly in this respect.

The relatively high content of ^{137}Cs was found in bell pepper (2,91±2,29 Bq/kg), cherry plum (2,58±2,07 Bq/kg) and maize grain (2,15±1,62 Bq/kg). However, these indicators are far below the maximum permissible level. For example, the permissible level of cesium-137 in a bell pepper is 130 Bq/kg, in cherry plum - 40 Bq/kg in, and in maize grain - 80 Bq/kg. This means that in the case of bell pepper, the specific activity of ^{137}Cs is 44 times lower than the permissible level (2,24% of the permissible level) established by radiation safety standards, in the case of cherry plum - 15,5 times lower (6,5% of the permissible level), and in the case of maize grain - 37 times lower (2,7% of the permissible level).

The content of radionuclide ^{90}Sr was comparatively high in the wheat grain - 11,30±11,40 Bq/kg, though this activity was 12 times lower than the permissible one (140 Bq/kg).

The radionuclides studied by us are practically not observed in food products of animal origin (milk, dairy products, meat, and meat products) produced in the Kakheti region. Proceeding from it, it might be concluded that the above-mentioned products are free of these radionuclides, and internal radiation doses, conditioned by ^{137}Cs and ^{90}Sr, which are found in locally produced products, would also be minimal.

As a result of the study, one peculiarity was revealed: the data on the specific activity of the radionuclide ^{137}Cs in food products are statistically reliable, but as for the data concerning the specific activity of the radionuclide ^{90}Sr in food products, the coefficient of their plausibility is less reliable.

When discussing the value of the internal radiation dose of the population, it should be borne in mind that, in addition to ^{137}Cs and ^{90}Sr, other radionuclides are involved in the formation of this dose as well. The metabolic processes, processes of assimilation, and dissimilation in the body should also be taken into account. Besides, along with the local products studied by us, the population also consumes imported products, the content of radionuclides of which we have not studied. Though, presumably, it is impossible to exclude the presence of radionuclides with a long half-life in these products, especially in those that were brought from territories contaminated as a result of the Chernobyl accident [7].

Conclusion

Thus, comparing the results of the study carried out to identify radionuclides in food products with the permissible specific activity of radionuclides, it can be seen that the content of radionuclides in local food products in the Kakheti region is much lower than allowed by radiation safety standards [8].

According to the results of the study, it can be assumed that the internal dose of radiation of the population conditioned by ^{137}Cs and ^{90}Sr would be relatively low. Though this fact does not give

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a reason for calm. To obtain a complete picture of internal doses of radiation, it is necessary to continue research with the aim of qualitative and quantitative identification of radionuclides in local and imported food products, as well as to study the actual nutrition of the population.

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