ASSURANCE OF CONTINUOUS INCOMING RADIATION CONTROL OF RAW MATERIALS AT MEAT-PROCESSING PLANTS

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Background

Manufacture of ecologically safe competitive meat products is an actual task. As a result of an accident at Chernobyl atomic power station, territories contaminated by long-lived radionuclides (so called raduonuclide anomalies) appeared both in Russia and abroad. Nuclei of long-lived elements ^{137}Cs and ^{90}Sr, whose half-life period is about 30 years, constitute a sizable proportion of them [1].
At present meat raw material, because of its deficit, arrives at plants both from domestic and foreign territories with various sources of environmental pollution by radioactive and other toxic substances. Radioactive contamination of cattle, delivered from such territories, and, consequently, meat raw material and finished products during their manufacture is one of the factors of radioactive danger for man. Practically, continuous incoming radiation control of meat raw material at meat-processing plants is lacking. State sanitary services embrace only part of all products, and the most part of them are realized without radiation control [2].

Objectives

Carrying out investigations of specific activity of ^{137}Cs with its different content in cattle and, correspondingly, that of raw material after cattle slaughter in native state. Development of a system of control levels and apparatus-methodical facilities for continuous incoming radiation control of raw materials at meat-processing plants.

Methods

Investigations of the content of specific activity of ^{137}Cs in cattle and raw materials were carried out by SKS-99 "Sputnik" portable multifunctional scintillation gamma-spectrometer and in a radiological laboratory using USK "GAMMA-PLUS" stationary universal spectrometric complex.

Results and discussion

Hygienic standards on the content of radionuclides in food industry and food raw materials were set in Russia. During their development initial prerequisites consist in the fact that in dosimetrically significant quantities in foodstuffs only radionuclides ^{137}Cs and ^{90}Sr may present. Taking into account each type of foodstuffs in a daily ration, the total possible contribution of radioactive foodstuffs at the expense of internal irradiation into the effective dose shouldn't exceed 1 mZv/year. Values of norms are given in SanPiN 2.3.2.560-96 [3]. According to [3], a foodstuff is good for consumption if specific activity values of ^{137}Cs and ^{90}Sr meet the following condition:

$$(Q/H)_{Cs\text{-}137} + (Q/H)_{Cr\text{-}90} \le 1, \qquad (1)$$

where Q is specific activity of ^{137}Cs and ^{90}Sr radionuclides in the given foodstuff; H are norms of specific activity of ^{137}Cs and ^{90}Sr radionuclides set for the above product.
The main difficulty we have when realizing these requirements in practice consists in the necessity of measuring, along with ^{137}Cs radionuclide, specific activity of ^{90}Sr radionuclide.
From the point of view of taking measurements technology, determination of specific activity of ^{137}Cs doesn't create particular difficulties as, according to the decomposition scheme $^{137}Cs \xrightarrow[30\ years]{} {}^{137m}Ba \xrightarrow{2.55\ min} \underline{{}^{137}Ba,}$ beta-decomposition of ^{137}Cs is accompanied by gamma-radiation of its daughter radionuclide ^{137m}Ba with photon energy $E_\gamma = 662$ keV and quantum output of 85%. Radionuclide ^{90}Sr and its daughter radionuclide ^{90}Y are pure "beta-radiators" $^{90}Sr \xrightarrow[28.2\ years]{} {}^{90}Y \xrightarrow{64.4\ h} \underline{{}^{90}Zr,}$ and determination of their specific activity by measurements of beta-radiation presents certain difficulties meaning, first of all, that a reply can be received minimum within an hour from the moment of sampling in laboratory conditions. A way out from the current situation is in taking into account of cesium and strontium metabolism peculiarities in the animal organism. Biochemical peculiarities of cesium in the animal organism manifest themselves in the fact, that specific activity of radionuclide ^{137}Cs is taken as approximately constant in all soft tissues of the above organism. That is, a carcass, half carcass, quarter carcass, meat block formed from one and the same animal are taken for the unit of meat raw material characterized by one and the same value of ^{137}Cs radionuclide specific activity.
At present radiation monitoring includes sampling of meat raw materials or meat products, transportation of samples to laboratories, preparation of countable samples from the sample substances and, at last, measurement of specific activity of radionuclides ^{137}Cs and ^{90}Sr in countable samples at stationary laboratory measuring complexes, including a gamma-spectrometer for measuring activity of radionuclide ^{137}Cs and a beta-spectrometer for measuring activity of radionuclide ^{90}Sr. Thus, the time interval between the sampling procedure and achieving measurement results is, as a rule, more than 24 hours. At the same time necessity of measuring specific activity of radionuclide ^{90}Sr stipulates the time interval only for taking measurements and preparation of an appropriate countable sample not less than an hour. Under the circumstances one may speak only about selective radioactivity control of meat products and meat raw material. In this case it is practically impossible to quantitatively determine reliability of control, that is, to determine the probability of "passing" radioactive meat products through the control system [4]. Thus, a necessary condition for the possibility of carrying out express control of meat raw material correspondence to the requirements of radiation safety in [3] is development of apparatus-methodical facilities for measuring ^{137}Cs specific activity directly on the carcass without sampling; giving up measurements of ^{90}Sr specific activity and its calculation by introduction of reserves by specific activity of ^{137}Cs. In other words, condition (1) is transformed into the following dependence:

$$(Q/КУ)_{Cs\text{-}137} \le 1 \qquad \text{at} \qquad (КУ)_{Cs\text{-}137} \le 160\ Bk/kg, \qquad (2)$$

where $(Q)_{Cs\text{-}137}$ is the value of ^{137}Cs specific activity in meat raw materials; $(КУ)_{Cs\text{-}137}$ is the control level of radionuclide ^{137}Cs specific activity in meat raw materials; $(H)_{Cs\text{-}137} = 160$ Bk/kg is the norm of radionuclide ^{137}Cs specific activity for meat raw materials and meat products [3].

Analysis of literary data showed, that at $(KY)_{Cs-137}$ = 100 Bk/kg in conditions of prevailing of accident fall-outs from Chernobyl atomic power station on the territory of the Russian Federation implementation of condition (2) with "reserve" guarantees implementation of condition (1). At the same time it is necessary to carry out purposeful investigations to decrease this "reserve" according to the real situation formed by the present time.

Apparatus-methodical facilities provide for utilization of SKS-99 "Sputnik" portable spectrometer with a special gamma-radiation detector based on Cs I (T1) 45 x 50 scintillation crystal. The detector is placed in a cylindrical lead collimator. When carrying out measurements in the animal's lifetime, the end of a collimated detector is located close to the animal in the part between the femur and tibia of the hip joint. Measurements of ^{137}Cs in carcasses are made in the same configuration. Algorithm of specific activity determination includes measurement of background taken in the same point of the animal carcass with a lead filter at the detector end.

Measurements of ^{137}Cs specific activity on different parts of cattle carcasses after slaughter were taken by SKC-99 "Sputnik" device. Separately skin was measured and a meat sample for measurement in a radiological laboratory on USK "GAMMA-PLUS" stationary device was taken. The meat sample specific activity was (126 ± 47) Bk/kg and corresponded to the results of measurements of cattle made with SKS-99 portable device. The results of measurements show that choice of the hip part was correct, because a sufficient "meat block" in which "cone" of sensitivity can be placed was there (see Table below).

Conclusion

Comparative measurements of ^{137}Cs specific activity in cattle lifetime and meat raw materials after slaughter were taken. A system of control levels was developed and apparatus facilities for measurements of continuous incoming radiation control both of meat raw materials for meat processing plants and in the cattle lifetime were selected.

Results of measurements of ^{137}Cs specific activity in meat raw materials using SKS-99 "Sputnik" portable device

Object	Measured value of ^{137}Cs specific activity, Bk/kg	Measurement error, Bk/kg	Measurement time, s
Point 1. (Shoulder part)	72	26	60
Point 2. (Sternocostal part)	40	26	60
Point 3. (Coxofemoral part)	126	47	60
Skin	0	30	60

Pertinent literature

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