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IMPROVEMENT IN QUALITY OF DAIRY CATTLE PRODUCTS IN AREAS WITH MAN-MADE RADIATION AND CHEMICAL POLLUTION

Isaeva Albina^{1,2}, Krivonogova Anna^{1,2}, Moiseeva Ksenya¹, Loretz Olga¹, Shkuratova Irina^{1,2}, Donnik Irina¹

¹Federal State Budgetary Educational Institution of Higher Education "Ural State Agrarian University" (FSBEI HE Ural SAU), 42, K. Liebnechta St., Ekaterinburg, Russian Federation

²Federal State Budgetary Scientific Institution "Ural Veterinary Research Institute" (FSBSI), 112 A, Belinskogo St., Ekaterinburg, Russian Federation
isaeva.05@bk.ru

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Abstract

A study of the quality and quantity indexes of the dairy cattle milk-producing ability was conducted in areas polluted with heavy metals and radionuclides. The condition of agrobiocenoses in the Eastern Urals Radioactive Trace was studied, and correlation between the pollution of the agrobiocenoses with Cd, Cu, Zn, Fe, ⁹⁰Sr, ¹³⁷Cs, ²¹⁰Pb, the content of the pollutants in the animal organisms and the quality of their milk was established. Trends towards the amino acid content alteration, protein and fat content reduction and the somatic cell number increase in the milk, deterioration of its microbial content, of its suitability for cheese production and grading were detected in the areas more heavily polluted with radionuclides and chemical pollutants.

An experiment with an integrated effect on the critical points of the technological process of milk and its primary product manufacture involving protection of the agrocoenosis from secondary pollution, improvement in the food quality, clearance of the pollutants from the animal organisms and metabolism care, high-technology processing of of milk and its primary products was conducted. It was established that a simultaneous effect on the critical points of the technological process significantly increases the effectiveness of individual methods due to synergy and leads to a significant improvement in the quality indexes of milk. In particular, in the experimental group, a 2%-to- 12% increase in the concentration of free essential amino acids and a 15-to-40-fold decrease of the somatic cell number in the milk, improvement in its suitability for cheese production and reduction in its microbial content compared with the controls were observed. In the context of permanent unavoidable man-made load on the agrobiocenoses, application of this technology permits maintaining the product quality at a high-standard level.

Introduction

The territories located in industrial areas are polluted with various chemical and physical factors due to scheduled and accidental emissions from various enterprises. It resulted in the formation of zones with combined chemical and radionuclide pollution of the soil, including the ones in agricultural lands (Moiseeva, 2016; Vorobeichik, 2016). Procurement of fodder for cattle in this kind of areas inevitably leads to increasing content of heavy metals and radionuclides in a ready-made feed mixture that has a negative effect on animals' health and quality of the products (Kaplan, 2011; Donnik, 2017). The East Urals Radioactive Trace (EURT) formed as a result of the Kyshtym disaster is one of the zones with combined chemical and radionuclide pollution. The peripheral parts of EURT are characterized by specific pollution of the agrobiocenoses, mostly polluted with Strontium-90 and Cesium-137 (approximately in equal proportion), as well as by pollution with heavy metals, such as Cd, Fe, Pb, Cu, Zn (Moiseeva, 2016; Vorobeichik, 2016; Belykh, 2015). The cattle of the farms located in the area of EURT, have some health problems caused by negative influence of the environment, that is proved by higher incidence of disease, reduction of productivity and lower quality of products (Zhang, 2014; Donnik, 2017).

Materials and methods

The research were done on plant feeding-stuffs, ready-made feed mixtures, organs and tissue of cows, milk, meat and by-products of cattle, as well as on the manure used as fertilizer. In the above-mentioned objects the content of Sr-90, Cs-137, Pb-210 was stated by means of radiochemical methods; and the content of Cd, Ferrum, Zn and Cu – by means of nuclear-emission methods of spectrometry. The health of the animals was evaluated by biochemical and immuno-haematological screening and there were also histologic study of the tissue. In the milk of the cows the content of heavy metals and radionuclides, somatic cells, protein, fat, amino acids was stated, and suitability for cheese production was researched according to the fermentation test.

Results

As compared with the same index in the intact territories, the areas with combined radionuclide and chemical pollution (the East Urals Radioactive Trace and surrounding territories) have higher activity of ^{90}Sr in corn silage and haylage - 12,70 Bq/kg and 12,50 Bq/kg correspondingly; of ^{137}Cs and ^{210}Pb –in haylage only: 4,41 Bq/kg and 4,45 Bq/kg correspondingly; whereas the content of iron was 1,9 times higher than the maximum allowable concentration. For the period of 1996-2016 in the EURT area the average activity in the feed mixtures reduced in ^{90}Sr – by 25,5 times, in ^{137}Cs – by 4,9 times. For the period of 2006-2016 in the zone of the most chemical pollution (the territory next to EURT) the average activity in the feed mixtures reduced in ^{90}Sr - by 1,5 times, in ^{137}Cs – by 3,3 times; and in ^{210}Pb –by 1,1 and 2,2 times.

The cattle in the farms located in the zone of combined chemical and radionuclide pollution had metabolic disorder in the forms of hypoproteinemia and changes in fermentation capacity of blood serum. The most frequent index of gamma glutamine transpeptidase and alkaline phosphatase among the animals from the zone with radionuclide pollution was 23,9 u/l and 96,5 u/l; from the surrounding territory - 19,4 u/l and 63 u/l; from the control zone - 17,5 u/l

and 65,0 u/l correspondingly. The content of protein in the cattle from the EURT area was 77,54 g/l; from the control zone - 83,81 g/l. The level of man-made effect defines the level of morphological changes in the organs of animals. The skeletal muscles have signs of myositis and inflammatory infiltrate in intermuscular connective tissue; the heart has signs of myocardiodystrophy; the liver has centrolobular fatty degeneration and granular degeneration with micronecrosis of hepatocytes; the kidneys have signs of fatty degeneration in epithelium of renal tubules.

Decrease in immuno-physiological resistance among the animals from the zone of the most combined pollution resulted in reduction of the period of economic use, increase of morbidity and reduction of a number of cows, including the ones affected with leucosis. For the whole period under research the average age of the lost cows in the EURT area was 0,3 – 0,5 lactation less, as compared with the ones in the control areas.

The products obtained from the animals from the zone with man-made pollution and from the clean one differed significantly. Generally, the milk of the cows from the EURT area and surrounding territories met the requirements of toxicological and biological safety and veterinary-sanitary quality, but the indexes of grading and biological value were lower. The weight percentage of fat in milk from the EURT area, in surrounding and control zones was 3,41%, 3,43% and 3,75% correspondingly, and the weight percentage of protein - 3,25%, 3,42% and 3,50% correspondingly. For the period of 2012-2016 the enterprises from the EURT area and surrounding territory gave 4% of highest grade from the total quantity of milk, whereas the ones from the “relatively clean” areas - 30-60%. The research done on the somatic cells in the milk of the cows from various zones showed that the percentage of the cows that give milk with low content of somatic cells is higher in the control zone. Thus, the interval containing 50 % of the samples under research (the areal closest to the mediane) was: in the EURT area – 130 000 - 170 000 cell/cm³; in the surrounding territory – 160 000-320 000 cell/cm³; in the control zone – 90 000-350 000 cell/cm³. The research conducted on aminoacid content of the milk of the cows showed that in the zones of chemical and radionuclide pollution the milk has reduced content of some amino acids, as compared with the milk from the intact zone: lysin – 5,3 times less; histidine – 3,5 times less; arginine - 1,5-2 times less; isoleucine - 4 times less; phenylalanine - 2 time less.

The content of the elements in the meat of the cattle from the areas with combined chemical and radionuclide pollution was higher than the same indexes obtained in the control zone: Cu – 1,9 times higher; Pb – 1,6 times higher; Cd – 1,7 times higher. The content of Cd in the liver of the cows was 3,2 times and 2 times higher correspondingly.

In the manure of the cows, which is used as fertilizer, from the EURT area the activity of ⁹⁰Sr was 8.5 times higher than the same index; of ¹³⁷Cs – 6.6 times higher. In the surrounding territory the average content of ⁹⁰Sr in the manure was 1.68 times higher than in the one from the intact zone; of ¹³⁷Cs – 1,62 times higher. Thus, it was stated that there is the case of migration of dangerous substances of chemical and radionuclide nature along trophic chains in agrobiocenosis that has a negative effect on animals' health and the quality of the obtained products.

In order to reduce the level of pollution of agrobiocenosis and prevention of health problems, as well as to increase the quality of the products, the integrated system of influence on the critical points of the technological process at the stage of feed production, cattle management and processing of the products was used. The complex of methods for protection of the cultivated areas from the secondary pollution with radionuclides and heavy metals, including the biological processing of the manure by strains of the soil microflora and physical-chemical fractionalization

with separation of solid body cleaned from pollutants and runoff water to be utilized, was implemented. To remove heavy metals and radionuclides from the body of cows, the 30-days' three-staged scheme of alimentary precaution based on successive courses of selective sorbent, methionine hydroxy analogue (MHA) and soya isolate was used. For processing milk primary products the alternative methods of sterilization that do not destroy native components of milk were used, such as sterilization by the nanosecond electron beam. The method showed significant germ-kill effect and preservation of biological value of milk. By the absorbed dose of 5-10 kGy the bacterial flora was completely eliminated, whereas the content of some amino acids increased: lysin – by 3 %, cysteine – by 8,5%, threonine – by 5%. The content of somatic cells reduced up to the detection limit. The indexes of the milk suitability for cheese production improved: after the use of the nanosecond electron beam, in 67 % cases, the initial samples of Grade 3 according to fermentation test, by the absorbed dose of 10 kGy showed Grade 1 of suitability for cheese production, and in 33 % cases – Grade 2.

Conclusion

The integrated effect on the critical points of the technological process of milk production in the areas with combined radionuclide and chemical pollution made it possible to increase some indexes of quality of milk and meat products obtained from cattle by decrease in pollution of links in agrobiocenosis, reduction of content of heavy metals and radionuclids in milk, meat and by-products. Elimination of metabolic disorders in body of animals resulted in growing content of some amino acids in milk, as well as in higher level of body resistance of cattle.

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