

ORIGINAL ARTICLE

Influence of natural environmental factors on gastropods molluscs

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Snails are an important component of ecosystem. They process considerable part of dying off organics and redistribute some substances in ecosystems. The protection of snails is the constituent of protection of the most valuable ecosystems which does the latter more complex and effective and lies in protection of their habitat, limitation of certain activities of people and in creation and maintenance of necessary conditions. Worsening of conditions of existence of snails can be foremost due to contamination of soil by radionuclides. As a rule, gastropods molluscs undergo mixed radioactive irradiation – external and internal.

Radioactive contamination of snails can change depending on type of maintenance (natural or artificial - in the conditions of a farm), degree of pollution of soil and plants which molluscs feed on. In the organism of gastropods molluscs radioactive substances get through alimentary canal with feed and water which include radionuclides. Certain amount of radionuclides can also get to the organism with particles of soil and wood. Probability of the consumption of radioactive particles from the surface of soil is high in case of radioactive rainfall.

It was determined that the best method to achieve ecologically clean product is to breed snails in the conditions of a farm. In this case every stage is controlled: getting litter, maintenance of all requirements concerning breeding, feeding and processing of snails on environmentally clean territories. It was well-proven that it is necessary to balance ration of snails with calcium and potassium in the conditions of a farm (in summer on the field) which is near polluted area that will lead to rapid elimination of ¹³⁷Cs and ⁹⁰Sr from their organisms. In case of radioactive pollution of gastropods molluscs the main task is not in taking care of them, but in the determination of the possibility to use meat from such snails for nourishment. It is obligatory before preparing ready-to-cook food, consuming or export the meat of snails to investigate them on the content of ¹³⁷Cs and ⁹⁰Sr, lead, zinc, copper, cobalt, iron, manganese and calcium. It is especially related to snails of natural population.

Keywords: Factors; gastropods molluscs; ecology; radionuclides; heavy metals

Introduction

Exceeding of average long-term content of substances in the components of ecosystems is called pollution. Pollutants are substances or their mixtures which in available amount (concentration) influence the environment negatively. Pollutants get to the ecosystem through the atmosphere, through superficial and underground water, and also through trophic chains. Therefore, harm which can be caused by pollutants and their separate components depend on properties of substances, peculiarities of components of ecosystems (soil conditions, season) and meteorological conditions (Prister, 1991; Hansard, 1964).

The source of industrial pollution of soil can be industrial waste water, drainage from polluted territories of enterprises and dumps of industrial wastes. The reasons of high level of pollution of environment are large gross emission of pollutants, violation of technological processes at enterprises, ineffective work of cleansing equipment (Vasenko, 2002).

Pollution of environment can be physical, chemical and radioactive. Physical pollution is thermal. For example, in the process of incineration of fuel thermal energy is out and it influences temperature regime and processes in air and water environments.

Among chemical pollutants gaseous and aerosol substances of industrial and domestic origin take an important place. Such substances include oxides of sulphur, nitrogen, compound fluorine, chlorine, carbon oxide and other toxic compounds (Yatsenko & Bogatko, 2017).

The source of radioactive pollution of environment is nuclear power plants and nuclear explosions. Scientific and technical progress caused significant transformation of production forces and affected all spheres of life of people and animals

(Edmond, 1994). The prime example of it is the wide use of sources of ionizing radiations in many industrial technologies, biology, medicine and agriculture.

Ionizing radiation is an inseparable part of environment during all period of its existence. Natural radiation background is determined by the presence of dissipated radionuclides of many chemical elements in rocks, ground, water and air, and also by a space radiation (Kraybill, 1962). Millions of years this radiation background did not change and the doses of radiation did not cause the expressed biological effects. However, for the last decades the level of radiation in the environment increased due to ionizing radiations from additional sources – radioactive wastes from nuclear power plants, enterprises of atomic industry and from radioactive emissions after atomic weapon trials, accidents at nuclear power plants, among which special place takes the catastrophe at Chornobyl nuclear power plant.

As a result of this accident about 50 radionuclides were dissipated unevenly. Nuclear fallout was indicated even in the countries of Asia, Eastern and Western Europe (Kimakovskaya, 2015).

After the accident at Chornobyl nuclear power plant considerable areas of agricultural lands underwent pollution that resulted in radionuclides contamination of animals and plants (Golovko & Zlotin, 2009).

Besides existent radionuclides which can be found in natural mixture of elements, there are many artificial radionuclides that are created during nuclear explosion, the most dangerous of them is caesium -137 (^{137}Cs) and strontium - 90 (^{90}Sr) (Bandazhevsky, 2001).

These radionuclides have relatively high energy of radiation and long period of half decomposition from a year to dozens of years. They are kept in the organism of a man and animal for a long time, they have a feature of inclusion in biological rotation of substances – soil →plants →animals →man (Owen, 1989). Therefore, determination of possible norms of these isotopes in gastropods molluscs is very important for the use of their meat in prepared products in future.

Purpose

The purpose of this work was to determine the ways of entering of radionuclides in the organism of man and snails, contamination of gastropods molluscs (snails) from different regions of Ukraine with radionuclides and heavy metals, to define measures to decline the content of radionuclides in the meat of snails. For achievement of this purpose the followings tasks were set:

- to analyze the ways of entering of radionuclides in the organism of snails;
- to define the content of radionuclides of strontium 90 and caesium 137 in the meat of snails of natural population and in artificial breeding;
- to investigate the contamination of snails of natural population *H. pomatia* with chemical pollutants in different regions of Ukraine.

Materials and methods

The research was conducted on the base of the Testing laboratory at Kharkiv branch of State research institute for laboratory diagnostics and veterinary-sanitary expertise, State research control institute of veterinary preparations and forage additions, National scientific center, Institute of experimental and clinical veterinary medicine.

In this work we used meat of snails which is nowadays in demand both in restaurants and in retail stores (prepared products can be purchased at supermarkets). For research on radionuclides– caesium - 137 and strontium - 90 we took 1.0 kg ± 0.2 of snails' meat of the species *Helix aspersa maxima*, *Helix aspersa muller* and *Helix pomatia*. The snails of the first two species were purchased at the farm «SNAIL 2016», *Helix pomatia* were collected in different regions of Ukraine. Test 1 – the meat of snails *H. pomatia*, Kazatske village, Berislavsky district, Kherson region; test 2 – meat of snails *H. pomatia*, Berezna village, Polonsky district, Khmelnytsky region; test 3 – meat of snails *H. pomatia*, Mala Danylivka, Dergachi district, Kharkiv region.

Snails differ considerably in size, shell color and body color, and also have different taste of meat. Thus, out of three species *Helix pomatia* is the biggest and its shell is unicoloured. If we take into account the snails *Helix aspersa maxima* and *Helix aspersa muller*, the body of the former species has a grey tint and the latter snails have a white tint.

Determination of radionuclides of snails of the species *Helix aspersa maxima*, *Helix aspersa muller* were conducted on the universal spectrometry complex «USK-Gamma+» by software «Progress» according to MI-GAMMA 2003 and MI-BETA 2004. The radiometric and spectrometry methods were used in the research. Investigation of snails' meat of *Helix pomatia* in order to determine the content of strontium and caesium was carried out on gamma-beta spectrometer MKS-AT1315 («Atomtex» company) according to PI 5.4-49/im/2014.

Results

Snails are an important component of ecosystems reprocessing considerable part of dying off organics and redistributing some substances in ecosystems. The protection of snails is very important for the most valuable ecosystems which makes it more complex and effective and includes the protection of their habitat, limitation of some activities of people and creation and maintenance of necessary regime. Worsening of conditions of existence of snails can be foremost due to contamination of soil by radionuclides.

For breeding snails special biofarms are used, but it is also possible to breed them in more simple conditions using sheds, basements, greenhouses, hotbeds, i.e. in conditions that are similar to natural.

Meat of snails has a high food value. It tastes like beef with mushrooms. It is very useful to eat raw meat as it contains biologically active substances and influences pathogenic microflora of intestines. Nowadays breeding of snails is connected

with permanent growth of demand on this product. Many countries of the world are engaged in artificial breeding of snails. We consider that there are many possibilities for the rational use of not only natural snails of *Helix* species but also for the artificial breeding of valuable food snails in Ukraine.

Biological efficiency of ionizing radiations is incredibly high. Ionizing radiation prevails all known types of radiations considerably. The range of stability to the action of ionizing radiation is very wide. Most sensible microorganisms, doses which can cause their death make up hundreds of gray, and the most stable are mammals (Law of Ukraine dated October 26, No. 2809-IV, 2005).

The degree of stability to the ionizing radiation varies within the limits of one species. For molluscs criterion LD50 is 120-200g and it depends on biological features of animals (Eberhardt, 1946). Despite the fact that gastropods molluscs do not have special receptors or analyzers for perception of ionizing radiations, they encounter ionizing radiation every day. First of all, it is so-called radiation background of Earth which consists of three components: space radiation, radiation from natural radioactive elements which are in soil, air and water, radiation from natural radioactive substances which get to the organism of snails with food and water and are kept there during all their life. Concerning radiation background, all forces must be directed to the diminishing of influence from the sources of radiation. In the last decades processes of biological effect of radiation from molecular and cellular level to the influence on population in general are studied significantly.

Gastropods molluscs are mainly influenced by mixed irradiative radiation – external and internal. Internal irradiation occurs as a result of getting strontium and cesium with food, namely with feed and water. External irradiation occurs due to radionuclides which are in the habitat of molluscs and due to things with which snails contact - plants, soil, air, fallout. The organism of molluscs reacts to the irradiation in various ways depending on different reasons: doses, power, amount of irradiation, general state of animal.

After small doses of irradiation and at certain terms, increase of growth, acceleration of development, increase of productivity can be observed that means that an ionizing radiation does a stimulant action. And if the doses of radiation exceed an acceptable level a striking effect is observed and large doses lead to death of animals.

The increase of level of radionuclide contamination of environment increases the risks of negative consequences for population that is under the influence of irradiation caused also by incorporated radionuclides ^{137}Cs and ^{90}Sr which get from soil into water, plants, atmosphere, get into forage and food chains creating the sources of permanent radioactive contamination (Szabo, 1982; Kovalenko, 1994).

In case of radiation contamination of considerable territories the mass radiation of molluscs with different levels can occur. As a result, important practical decisions must be taken concerning possibility of the use of products which were obtained from the affected snails. In such case a substantial value acquires veterinary-sanitary expertise of snails' meat, especially in case of internal contamination with radionuclides, as in this case one of main factors of estimation of product is a level of its radioactive contamination which is determined with the help of radiometric research.

Radioactive substances get into the organism of gastropods molluscs through digestive tract with feed and water, which contain radionuclides. Certain amount of radionuclides can also get to the organism with particles of soil and wood. Possibility of the intake of radioactive particles from the surface of soil is significant in case of radioactive fallout.

Radioactive contamination of snails can change depending on the type of maintenance (natural or artificial - in the conditions of the farm), level of pollution of soil and plants which molluscs feed on.

A shell of a snail is a main place for accumulation of radioactive strontium and it depends proportionally on the level of calcium feed. Satiation of the ration with calcium gives a chance to decrease the accumulation of active strontium in the shell. The protective action of calcium is observed with the use of different types of mineral additives.

Additives of calcium to the ration are effective only if there is a lack of this element. ^{137}Cs is accumulated in the muscles of snails that is in the part which is considered edible. This alkaline element is excreted through animal kidneys. High content of potassium in the ration increases the speed of excretion of caesium from the organism and in such way diminishes its accumulation. This radionuclide is adsorbed in soil that should be taken into account in breeding and expertise of snails.

It should be kept in mind that as a result of intensive getting out of radionuclides with excrements, it can be the reason of contamination of soil and also the cause of the second disorder of molluscs.

Snails which grew or were collected in the areas of radioactive pollution should be taken for radiation control.

All measures directed to the decline of content of artificial radionuclides in snails' products can be divided into such groups:

- primary dosimetry;
- administrative;
- intensification;
- snails breeding.

Conducting of primary dosimetric control is necessary for non-admission of snails' meat with the content of radionuclides which exceeds possible norms. Such control must be undertaken from all sources, from which snails can be obtained for meat processing or for export. It is necessary to know the exact place of collection of snails, especially in case of gastropods molluscs which were bred in natural conditions.

Administrative measures are directed to the prohibition of collection of snails from polluted territories. These measures can be permanent or temporal depending on the changes of radiation situation.

Intensification measures are directed to the use of the mineral additives for the improvement of feed base and at the same time it can diminish the amount of radionuclides in snails.

In snails breeding it is necessary to take into account the fact that snails which were bred on the special artificial farms have many advantages compared to those which were collected in natural conditions. In the conditions of the farm snails

constantly get mineral additives and radionuclides-free water, special attention is paid to the state of health, farms are on clean caesium-free and strontium-free territories.

The research of meat of food snails of *Helix* species: *aspersa maxima*, *aspersa muller*, *pomatia* was conducted and the results are indicated in the Table 1.

Table 1. Content of strontium and cesium in meat snails.

Snail species	Content index, Bk/kg			
	¹³⁷ Cs			⁹⁰ Sr
	Admissible levels	Obtained data	Admissible levels	Obtained data
<i>H. aspersa maxima</i>	150	4.8	35	2.9
<i>H. aspersa muller</i>	150	5.7	35	3
<i>H. pomatia</i>	150	1.54	35	9.7
M ± m	150	4.01 ± 1.26	35	5.2 ± 2.25

Thus, according to the obtained data indicated in the table 1 it is possible to conclude that examined meat of snails does not exceed admissible level in relation to radionuclides of strontium – 90 and caesium – 137. It is evident that the biggest quantity of caesium is in snails' meat of *Helix aspersa muller*, and strontium –in snails' meat of *Helix pomatia* and makes up 5.7:9.7 Bk/kg respectively.

Consequently, for export or preparing semi-finished products snails' meat must be obligatory checked for ¹³⁷Cs and ⁹⁰Sr. Snails' meat can be used only after expert conclusion from the laboratory to confirm that the content of ¹³⁷Cs and ⁹⁰Sr does not exceed admissible levels and is not higher than 150:35 Bk/kg respectively.

Contamination of product of animal origin – snails' meat occurs mainly in biological way. In natural conditions and also in the conditions of a farm in summer, when snails are on the field and they can be under the influence of radioactive dust the level of contamination is much higher than in the conditions of a farm.

In the conditions of contamination of territory by radioactive products an important element is to sort molluscs with the purpose of determination of optimal options of their use.

Radionuclides in the organism of snails lead to decline of fecundity and development of nonviable young snails. In prognosis the effects of radiation damage of snails it is necessary to take into account not only the nearest but also the furthest consequences. It is especially important at maintenance of molluscs or at their collection on polluted with radioactive substances territories.

Radioactive products of nuclear fission which fall out by themselves («dry» fallout) or more frequently with atmospheric fallout («wet» fallout) are included to the components of biosphere – abiotic (soil, water) and biotic (flora, fauna) and take part in the biological circle of rotation of substances. Thus, the products of fission can get into the organism of man both directly through vegetables and through animals which consume plants that contain radionuclides (Figure 1).

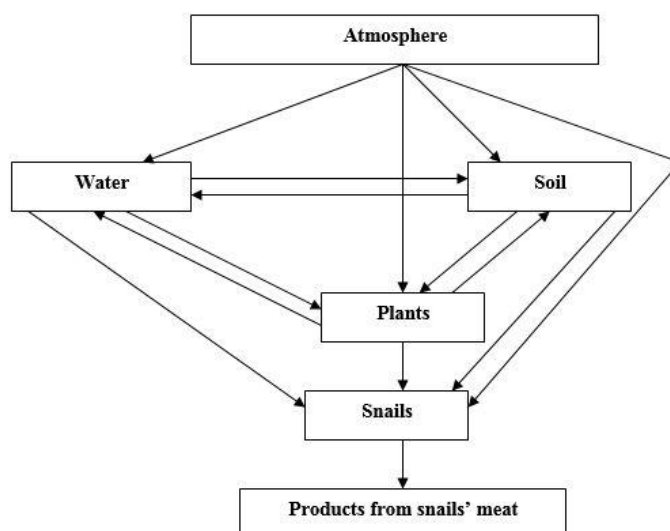


Figure 1. Ways of getting of radionuclides in the organism of snails.

Meat of snails, the quality of which does not meet the requirements must be taken away from the market. The possibilities of the use, utilization or elimination of such meat acknowledged as inappropriate for food aims are considered by their owner and must be approved by territorial establishments of the State service of Ukraine for food safety and consumer protection. The results of radiation control (research, tests) are processed with a protocol in accordance with the requirements of DSTU ISO/IES 17025. For measuring specific activities of radionuclides ^{137}Cs and ^{90}Sr in food and water the metrology attested methods of implementation are assumed that meet the requirements of providing the unity of measuring and correspond the Ukrainian state standards and provide authenticity of control of specific activity that is characterized by reliable probability not less than 0.95.

Norms are provided with the purpose of subsequent decline of dose of internal irradiation of population of Ukraine by limitation of radionuclides in food and stimulation of creation and maintenance of necessary conditions to get clean products from radioactive polluted territories.

Hundreds of pollutants including heavy metals can get to the organism of snails. There can be cuprum, zinc, cobalt, manganese, iron and also sources of dust of different factories, plumbum and calcium. The results of content of chemical pollutants in snails' meat from different regions of Ukraine are indicated in the Table 2.

Table 2. The content of chemical pollutants in snails' meat *H. pomatia* from different regions of Ukraine.

Sample Element, mg/kg	Sample 1	Sample 2	Sample 3
Plumbum	0.025 ± 0.01	Was not found	1.59 ± 0.08
Zinc	16.5 ± 0.38	18.1 ± 0.3	73.98 ± 0.64
Cuprum	5.02 ± 0.45	5.61 ± 0.65	3.96 ± 0.21
Cobalt	0.21 ± 0.01	0.25 ± 0.02	0.34 ± 0.02
Iron	39.78 ± 0.37	24.01 ± 0.47	46.82 ± 1.11
Manganese	8.55 ± 0.25	26.03 ± 0.38	38.86 ± 0.2
Calcium	7367.13 ± 205.5	6544.54 ± 157.45	6956.26 ± 145.23

It is shown in the table 2 that among all elements except cuprum and calcium the highest indexes are observed in the sample 3. Thus, the most polluted territory with chemical elements is Mala Danylivka, Dergachi district, Kharkiv region. According to Obligatory minimum list of research of raw materials, products of animal and vegetable origin, mixed fodder raw materials, mixed fodders, vitamin preparations, etc. which must be conducted in the state laboratories of veterinary medicine and according to its results veterinary certificate is given out (f-2), possible levels are indicated only for plumbum, the amount of this element is within the limits of possible levels, and in the sample 2 it is absent.

Conclusion

- It is obligatory before preparing ready-to-cook food, use or export snails' meat must be probed on the content of ^{137}Cs and ^{90}Sr , plumbum, zinc, cuprum, cobalt, iron, manganese and calcium. It is especially important in case of snails of natural population.
- The best way to get ecologically clean product is to breed snails in the conditions of a farm. Thus, every stage is controlled: getting of young snails, maintenance of all requirements concerning breeding, feeding and processing of snails on ecologically clean territories.
- It is obligatory in the conditions of a farm (in summer on the field) which is located near polluted area to balance ration of snails with calcium and potassium - it will lead to more rapid excretion of ^{137}Cs and ^{90}Sr from their organism.
- In case of radioactive contamination of gastropods molluscs it is more important to determine if it is possible to use the meat of such snails for food purposes in future than just to take care of them.

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