**Food and Nutrition Sciences, 2015, 6, 168-178**
Published Online January 2015 in SciRes. http://www.scirp.org/journal/fns
http://dx.doi.org/10.4236/fns.2015.61018

# Intake of Cl, Br, I, Se in Human Body with Food in Central Regions of the European Part of Russia

**Anatoly V. Gorbunov[1], Sergey M. Lyapunov[1], Marina Frontasyeva[2*], Sergey S. Pavlov[2]**

[1]Geological Institute of the Russian Academy of Sciences, Moscow, Russia
[2]Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Dubna, Russia
Email: [*]marina@nf.jinr.ru

Received 30 December 2014; accepted 19 January 2015; published 22 January 2015



## Abstract

**Since most of the central regions of the European part of Russia are considered selenium and iodine deficient, the assessment of modern real consumption of chlorine, bromine, iodine and selenium by population of these regions with different diets is an important constituent part of medical monitoring. In this paper, a brief analysis of the impact of these elements on the human body is given. A number of consumed foodstuffs in different food rations (diets) were assessed. Six selected basic food rations, which most fully reflect the specific features of nutrition in the Russian Federation, were chosen. The analysis of the concentration of chlorine, bromine, iodine and selenium in a wide range of food and agricultural products was carried out. The daily intake of these elements in the human body from the selected diets was calculated. A comparison of the real income of chlorine, bromine, iodine and selenium in the human body with a physiologically needed intake was performed. It is proposed to use the coefficient of $K_r$, which is the ratio of actual intake of the element in the human body to physiologically needed intake. Based on this analysis assessed insufficient or excess supply of chlorine, bromine, iodine and selenium in the human body with these diets in the central regions of the European part of Russia was evaluated.**

## Keywords

**Trace Elements, Intake, Chlorine, Bromine, Selenium, Iodine, Foodstuffs, Diets**

## 1. Introduction

Changes occurred in the 20th century in agricultural technology have led to a radical change in the natural bio-

[*]Corresponding author.

**How to cite this paper:** Gorbunov, A.V., Lyapunov, S.M., Frontasyeva, M. and Pavlov, S.S. (2015) Intake of Cl, Br, I, Se in Human Body with Food in Central Regions of the European Part of Russia. *Food and Nutrition Sciences*, **6**, 168-178.
http://dx.doi.org/10.4236/fns.2015.61018

geochemical food chains depending on the geographical features of human habitations. Modern agricultural technologies are impossible without using mineral fertilizers, pesticides, herbicides, and pre-treatment systems of planting material. The application of these technologies is already a powerful ecological and geochemical factor leading to changes in soil state of the region, changing its trace element composition and acid-base balance.

Radical changes have taken place in the technology of food production. Some products are refined and degreased; others are enriched with vitamins, trace elements, and biologically active additives. All these processes lead to a change in the macro- and microelement composition of foodstuffs consumed. Consumption of these products may change the balance of micronutrients in the human body, which increases the likelihood of various kinds of pathologies [1]-[3]. It is now believed that the majority of regions of Russia are iodine and selenium deficient [3]-[6]. At the same time, it is believed that the delivery of chlorine to the human body in Russia, conversely, is excessive [4] [7] [8]. Reliable information on the intake of bromine in the human body with food in Russia is practically absent. These listed elements except of bromine are considered vital. At the same time, depending on dose and time of exposure, they can be toxic. Moreover, the difference between the required intake and toxic dose is relatively small, for example, for iodine, this difference is of factor of 10 (0.2 g/day - 2 g/day). Therefore, the evaluation of the real income of chlorine, bromine, iodine and selenium in the human body is of current interest.

### 1.1. Element Features and Their Biological Functions

***Chlorine.*** Due to the high activity of chlorine it is not found in a free state in nature. Its natural compounds are widely known: chlorides of alkaline and alkaline-earth metals with the most common rock (table) salt NaCl, sylvinite (a mixture of potassium and sodium chlorides), and carnallite $KCl \cdot MgCl_2 \cdot 6H_2O$. Chlorides of other metals can occur as admixtures to these minerals. The Clarke number of chlorine in the Earth crust is 0.013%, sea water contains up to 1.8% of chlorine [1] [2]. Under normal conditions, chlorine is a gas with a yellow-green color and a sharp smell and is toxic. It is 2.5 times heavier than the air. Chlorine is considered to be one of the most important nutrients and it is a part of all living organisms. It is involved in metabolism, is a part of the biologically active compounds of the body and is an essential chemical element. Chlorine acts in maintaining acid-base balance between blood plasma and red blood cells, osmotic balance between the blood and tissues, and the water balance in the body. The chlorine metabolic disturbance leads to edemas. Chlorine contributes to the excretion of urea from the body, normalizes digestion by activating the amylase enzyme, it is involved in the formation of hydrochloric acid, the main component of gastric juice, by stimulating appetite. Dynamics of chloride content in the body depend on the gastric juice acidity: the higher the acidity is, the higher the further chloride consumption becomes. During the inflammatory process (peritonitis, perforated gastric ulcer and duodenal ulcer), a decrease in the chlorine content in the body occurs. Daily chlorine intake is 3 - 6.6 g while the required chlorine intake is estimated at 3.2 g per day, and the average content of chlorine in the body is 95 g [3] [4] [7]-[9].

***Bromine.*** It is not found in a free state in nature. It does not form any independent minerals, and its compounds (mostly with the alkaline metals) are chlorinated mineral impurities such as rock salt, sylvinite and carnallite. Bromine compounds are also found in the waters of some lakes and drill holes. Bromine is a volatile reddish-brown liquid with an unpleasant, suffocating smell [1] [2]. The biological role of Br in the living organisms is not understood well enough. It is known that Br is a constant part of normal gastric juice causing its acidity along with Cl. Br compounds inhibit thyroid function and enhance the hormonal activity of the adrenal cortex. Bromine is used in medicine for a long time as an insomnia and nervous exhaustion remedy to restore normal relations between excitation and inhibition in the cerebral cortex. The mechanism of bromine effect on the central nervous system is associated with its accumulation in the lipid part of brain cell membranes, thus activating the membrane enzymes. Furthermore, bromine is detected the human body in blood, kidney, and thyroid. Bromine being a competitor of iodine regulates the thyroid gland by reducing the iodine capture in the thyroid gland, thus preventing the improvement of the iodine level in the thyroid and contributing to the prevention of endemic goiter. Br content in the human body is about 260 mg, the required intake is currently not defined, and the average daily intake is 0.8 - 24 mg. The toxic effect occurs by the dose of 3 g per day, and the lethal dose is more than 35 g [3] [4] [9].

***Iodine.*** Iodine compounds do not form separate deposits, and occur as impurities in the chlorine minerals. The drill hole waters contain iodine salts. Iodine is a dark gray solid crystalline substance with a weak metallic glitter. Its chemical properties are similar to those of chlorine and bromine but iodine is less active. Its Clarke number in the Earth crust is 0.4 ppm. It is present in all living organisms, most of all in the algae (up to 5000 ppm) [1] [2] [7]. Iodine is an essential trace element for human beings. Iodine regulates the thyroid and pituitary gland functions, it is a structural component of thyroid hormones, and it prevents the accumulation of radioactive iodine. In areas where there is a lack of iodine in food and water the endemic goiter develops [5] [10] [11]. The carbohydrate diet, lack of animal proteins, vitamins C and A, and excessive intake of fat contribute to the development of the disease. The reason of iodine lack in some areas is the high solubility of iodine compounds in the water. Therefore, in the mountains or rocky areas located far from the sea, they are just washed away by the rain and water flows. For children, iodine deficiency leads to profound disorder of higher nervous activity and incomplete development of brainpower (cretinism). For adults, iodine deficiency leads to psychic inertia, slow response, decrease of mental abilities and strength, reduction of heartbeat rate and strength, and diastolic hypertension. At the same time, the cholesterol oxidation is inhibited and the accumulation of its atherogenic forms increases, which leads to early atherosclerosis, and in combination with disorders in the cardiovascular system to myocardial infarction and stroke. Iodine deficiency causes immunodeficiencies, increases the risk of tumor development, especially in the thyroid gland. The endemic goiter is a nosological form of iodine deficiency manifestation, a very common disease in some regions of Russia. An iodine deficiency causes serious health state called hypothyroidism named because of the lack of thyroid hormones (iodine is needed for their synthesis). The human body contains 20 to 35 mg of iodine. Its distribution in the body is very uneven: the least of iodine is found in the blood and kidneys, the most is concentrated in the thyroid gland (10 - 15 mg). The range of the required daily intake for people is 0.06 - 0.2 mg per day. One should not forget that iodine has a toxic effect. Thus, an instantaneous intake of about 2 - 3 g of iodine is usually lethal. There is also evidence that iodine is metabolically associated with selenium: iodine does not act in the organism without selenium [3] [12]-[14].

***Selenium.*** Until the mid-80s of the last century selenium was considered as a toxic element, nowadays it is recognized as one of the most important food antioxidants, it helps to eliminate oxygen derivatives (free radicals) from the body. The selenium Clarke number in the Earth crust is 0.1 ppm. In friable alkaline well-aerated soils selenium is present largely in the form of selenates that are highly soluble and easily absorbed by plants. In acidic waterlogged soils selenium is in the form of hardly soluble complexes with iron that possess an extremely low availability for the plants [1]-[3]. An important selenium deficiency in the human diet may cause the development of deficiency states, such as Keshan disease (cardiomyopathy) and Kashin-Beck syndrome (osteoarthropathy) [3] [6] [13] [15]. It should be mentioned that selenium is an antioxidant of indirect action. Its compounds taken with food are not antioxidants, but selenoproteins synthesized directly in the human body from the compounds taken with food are active antioxidants. A selenium deficiency affects in the first place the rural population, which mostly consumes the locally produced grain grown on soils with the low selenium content [6] [12] [16]. “Classical” areas for the spread of Keshan disease are some provinces of China. Another region affected by selenium deficiency was Finland (before the state program of soil enrichment with selenium compounds). In the Russian Federation, Keshan disease cases are found in Buryatia and Chita region. Other regions of Russia are characterized by the so-called “marginal” status of selenium that is not accompanied by any specific pathology, but is able to reduce the overall anti-infectious and anti-tumor resistance of the organism, its resistance to stress [6] [12].

In some countries, such as Finland, the issue was resolved by adding selenium-containing fertilizers to the soil. In our country, the wide use of selenium-containing dietary supplements seems to be more acceptable. However, most of the commercially available in Russia dietary supplements are mixtures of inorganic selenium salts with organic filler (topinambour, etc.). Obviously, they should not be considered as substances with organic selenium, because in this case no incorporation of selenium into the organic compounds occurs [12]. The human body contains about 14 mg of selenium. The required selenium intake is 0.06 - 0.15 mg per day, deficiency effect manifests by less than 0.01 mg per day of selenium, and the toxic effect occurs by 55 mg per day [12] [13] [17].

Thus, according to the participation in biological processes chlorine belongs to the structural elements, iodine is an essential element, and selenium is one of the most effective antioxidants needed for the normal functioning of iodine. The bromine role in biological processes is currently not clearly established, however, it is widely used in medicine, and its substantial presence in all biological objects is recorded by many researchers and cannot be questioned. Since chlorine, bromine, iodine and selenium enter our body mainly through the digestive tract, deficiency of these elements occurs mainly due to malnutrition.

### 1.2. Goal and Tasks of the Study

As follows from literature, the nutrition of the average person in the European part of Russia should be considered as sufficient or overabundant according to chlorine intake, absolutely scarce according to iodine intake and close to scarce according to selenium intake [3] [5] [6] [8] [9].

Of course, this is true only in a very general way. Obviously, the intake level of these elements into the human body depends entirely on the quality of the diet and drinking water consumed. Both factors have a high variability and depend on the region where the people live. Therefore, the goal of this study is to assess the real income of this group of elements into the human body in the European Russian regions taking into account different diets specific to these regions. The trace element income with drinking water into the human body is a separate big topic and is not considered in this paper. To achieve the stated goal of this work, the following tasks were:

- Sampling and analysis of food;
- Analysis of the existing range of basic food diets and selection of the most common diets for the population;
- Calculation of chlorine, bromine, iodine and selenium incomes for each selected diet in the test region;
- Comparison of the actual and required daily intake of chlorine, bromine, iodine and selenium in the human body with given diets based on these calculations.

## 2. Materials and Methods

Specificity of food consumption in large and medium-sized cities on the one hand, small towns and rural areas, on the other hand, has substantial differences. In the first case, people have free access to all retailers and services that exist in this city. Choice of retailers and the food is random, depending on personal preference and level of income of a particular individual. In the second case, a large share of the population nutrition is food products grown on private garden plots and farms. Therefore, during this study, sampling of foodstuffs was arranged by random sampling from the retail network of cities, farms and personal areas of central Russia. Every sample was taken from different places in the total number of samples 10 - 30. A total of about 2000 individual samples were collected. List of food items was selected based on the specifics of the nutrition of the Russian population [4] [18] [19].

### 2.1. Sampling Sites

Sampling of foodstuff was performed in retail outlets, personal and farming enterprises of the central part of the European Russia. The sampling of vegetables, fruits and berries was carried out directly in the places where they grow and in retail outlets. The sampling of the fungi mycothalluses was carried out in places where they grow in the Moscow, Kaluga, Tver, Gorky, Tula, Voronezh Oblast, the White Sea State Reserve and Karelia. Samples of meat, meat products, marine fish, milk products, bread and cereals were selected in the retail network in Moscow, Podolsk, Kaluga, Gus-Khrustalny and some other cities of the European part of Russia. River fish was partly taken from retail outlets, partly caught in the Oka River, Moskva River, Osyotr River, the upper and lower reaches of the Volga River and the Akhtuba River.

### 2.2. Sample Preparation for Analysis

A general list and the number of food samples are given in the **Table 1**.

Food samples were stored collected in plastic zip-lock bags, were cleaned from external contamination, washed with distilled water, dried at 60˚C and grinded up to a size of <1 mm. Samples prepared in this way were received for analysis.

### 2.3. Elemental Analysis

Analysis of trace element composition of the samples was carried out in the laboratory of the Geological Institute of the Russian Academy of Sciences (Moscow) and in the Frank Laboratory of Neutron Physics (FLNP) of the Joint Institute for Nuclear Research (JINR) (Dubna) using the instrumental neutron activation analysis. The analysis was performed at the research reactor IBR-2 of the FLNP in the JINR. Induced activity was measured with spectrometers based on ultrapure germanium detectors of the large volume of the companies “Canberra” and “Ortec” with an energy resolution of 1.3 - 1.5 keV for the $Co^{60}$ 1332 keV line. The experimental facilities are described elsewhere [20].

**Table 1.** List of food samples.

| No. | Foodstuffs | Number of samples (n) | No. | Foodstuffs | Number of samples (n) |
|---|---|---|---|---|---|
| | Cereals, bread | | | Mushrooms | |
| 1 | Oats grains | 10 | 47 | Cepe | 29 |
| 2 | Oats flakes | 11 | 48 | Brown cap boletus | 20 |
| 3 | Buckwheat | 12 | 49 | Orange cap boletus | 11 |
| 4 | Rice | 18 | 50 | Yellow boletus | 7 |
| 5 | Millet | 9 | 51 | Saffron milk cap | 5 |
| 6 | Semolina | 7 | 52 | Agaric honey | 13 |
| 7 | Noodles | 12 | 53 | Paxil | 12 |
| 8 | Wheat grain | 7 | 54 | Chanterelle | 17 |
| 9 | Wheat flour | 5 | 55 | Russule | 15 |
| 10 | Wheat bread | 9 | 56 | Coral milky cap | 6 |
| 11 | Rye grains | 5 | 57 | Champignon | 21 |
| 12 | Rye flour | 6 | 58 | Oyster mushroom | 11 |
| 13 | Rye bread | 11 | 59 | Champignon (agrofirm) | 11 |
| | Vegetables, greens, legumes | | 60 | Oyster mushroom (agrofirm) | 10 |
| 14 | Potatoes | 63 | | Fish, seafood | |
| 15 | Beet | 24 | 61 | Pike | 7 |
| 16 | Cabbage | 22 | 62 | Asp | 6 |
| 17 | Celery cabbage | 10 | 63 | Sabrefish | 7 |
| 18 | Garden radish | 11 | 64 | European carp | 6 |
| 19 | Radish | 21 | 65 | Roach | 7 |
| 20 | Aubergines | 9 | 66 | Bream | 9 |
| 21 | Tomatoes | 26 | 67 | Pikeperch | 5 |
| 22 | Carrots | 57 | 68 | Sheatfish | 5 |
| 23 | Maize | 18 | 69 | Zope | 5 |
| 24 | Spinach | 19 | 70 | River perch | 9 |
| 25 | Parsley | 22 | 71 | Cod | 11 |
| 26 | Bulb onion | 15 | 72 | Herring | 5 |
| 27 | Garlic | 9 | 73 | Mullet | 7 |
| 28 | Lettuce | 24 | 74 | Grouper | 6 |
| 29 | Dill | 20 | 75 | Flatfish | 5 |
| 30 | Haricot | 13 | 76 | Alaska pollack | 10 |

**Continued**

| | | | | | |
|---|---|---|---|---|---|
| 31 | Lentil | 5 | 77 | Mackerel icefishe | 6 |
| 32 | Peas | 5 | 78 | Shrimps | 14 |
| 33 | Soya beans | 16 | 79 | Squid | 5 |
| | Fruits, berries | | | Meat, byproducts | |
| 34 | Apple | 19 | 80 | Beef (meat) | 23 |
| 35 | Pear | 17 | 81 | Pork (meat) | 18 |
| 36 | Plum | 9 | 82 | Chicken (meat) | 15 |
| 37 | Citruses | 32 | 83 | Turkey (meat) | 13 |
| 38 | Banana | 15 | 84 | Beef tripe | 9 |
| 39 | Cranberries | 10 | 85 | Beef liver | 13 |
| 40 | Strawberries | 16 | 86 | Beef kidneys | 11 |
| 41 | Wild strawberries | 6 | 87 | Beef heart | 17 |
| 42 | Honeysuckle | 17 | 88 | Beef lung | 7 |
| 43 | Raspberries | 10 | 89 | Hen's eggs | 12 |
| 44 | Currants | 16 | 90 | Sausages | 28 |
| 45 | Cherries | 8 | | Milk products, coffee, tea, sugar | |
| 46 | Gooseberries | 10 | 91 | Dried milk | 10 |
| | | | 92 | Milk products | 15 |
| | | | 93 | Coffee | 30 |
| | | | 94 | Tea | 39 |
| | | | 95 | Sugar | 11 |

The QC/QA of the results was performed by analyzing the encrypted standard samples. The quality and reliability of the analytical work were systematically confirmed during the analytical tests as part of the international cooperation programs [21] [22].

## 3. Results and Discussion

**Table 2** shows the concentration of Cl, Br, I and Se in the main foodstuffs. The presented data concern the reduced number of foodstuffs (in comparison with **Table 1**) for convenience of the further calculation of elements intake with food. Some food categories have been grouped (fruits, berries, salt-water and river fish) and the concentration values were summarized. It should be taken into account that the data include the humidity of the foodstuffs except for cereals, noodles, legumes, coffee, tea and sugar that contain the data for the air dry weight.

These concentrations give an idea of the food poor or rich in Cl, Br, I and Se. This is important when choosing a product for a balanced diet. For example, high levels of all three halogens are in seafood and dried milk. In addition, high levels of Cl is observed in bread, chicken meat and byproducts, Br is present in oats flakes, rice, millet, semolina, peas, soya beans, coffee and tea, and I is found in oats flakes, turkey meat and tea. The highest content of Se is found in cepes, wild champignons, meat byproducts, river fish and shrimps.

However, the values of these data are not high enough in case when there is no information on the population diets. Obviously, in order to calculate the elements intake in the human body it is necessary to know the structure of the diet.

**Table 2.** The content of Cl, Br and I in foodstuffs, mg/kg (with humidity).

| Foodstuff | **Cl** | **Br** | **I** | **Se** |
|---|---|---|---|---|
| Oats flakes | 497 ± 82 | 6.45 ± 2.1 | 0.047 ± 0.012 | <0.02 |
| Buckwheat | 45 ± 12 | 0.41 ± 0.39 | 0.002 ± 0.002 | <0.02 |
| Rice | 362 ± 140 | 20.4 ± 12 | 0.003 ± 0.002 | 0.23 ± 0.12 |
| Millet | 393 ± 42 | 19.1 ± 2.2 | 0.005 ± 0.003 | 0.26 ± 0.05 |
| Semolina | 603 ± 180 | 14.4 ± 4.2 | 0.009 ± 0.004 | <0.02 |
| Noodles | 516 ± 68 | 2.33 ± 1.22 | 0.002 ± 0.001 | 0.16 ± 0.11 |
| Wheat bread | 1450 ± 510 | 4.33 ± 0.72 | 0.003 ± 0.002 | <0.02 |
| Rye bread | 1300 ± 510 | 2.85 ± 0.92 | 0.013 ± 0.011 | <0.02 |
| Potatoes | 392 ± 207 | 0.27 ± 0.21 | 0.002 ± 0.001 | <0.02 |
| Cabbage | 750 ± 320 | 0.13 ± 0.05 | <0.003 | <0.02 |
| Tomatoes | 225 ± 38 | 0.34 ± 0.22 | <0.003 | <0.02 |
| Carrots | 753 ± 481 | 0.25 ± 0.23 | 0.004 ± 0.003 | <0.02 |
| Haricot | 990 ± 210 | 0.42 ± 0.23 | 0.035 ± 0.02 | <0.02 |
| Peas | 365 ± 160 | 15.2 ± 3.8 | 0.006 ± 0.002 | <0.02 |
| Soya beans | 510 ± 100 | 1.56 ± 0.45 | 0.003 ± 0.002 | 0.15 ± 0.13 |
| Fruits | 34 ± 11 | 0.066 ± 0.04 | 0.003 ± 0.001 | 0.024 ± 0.01 |
| Berries | 78 ± 14 | 0.093 ± 0.08 | 0.002 ± 0.001 | <0.02 |
| Cepe | 188 ± 141 | 1.61 ± 1.28 | 0.0069 ± 0.006 | 1.08 ± 0.75 |
| Champignon | 300 ± 197 | 0.37 ± 0.33 | 0.011 ± 0.009 | 0.65 ± 0.55 |
| Champignon (agrofirm) | 189 ± 141 | 0.19 ± 0.07 | 0.006 ± 0.004 | 0.19 ± 0.14 |
| Oyster mushroom | 35 ± 7.8 | 0.048 ± 0.02 | 0.005 ± 0.003 | 0.061 ± 0.013 |
| Oyster mushroom (agrofirm) | 36 ± 5.6 | 0.048 ± 0.012 | 0.002 ± 0.001 | 0.034 ± 0.021 |
| Beef (meat) | 478 ± 105 | 0.89 ± 0.19 | <0.003 | 0.027 ± 0.009 |
| Pork (meat) | 715 ± 128 | 1.67 ± 0.15 | 0.015 ± 0.008 | 0.12 ± 0.04 |
| Chicken (meat) | 1530 ± 227 | 4.04 ± 3.32 | 0.011 ± 0.01 | 0.12 ± 0.05 |
| Turkey (meat) | 424 ± 148 | 0.59 ± 0.33 | 0.029 ± 0.012 | 0.071 ± 0.03 |
| Byproducts | 1646 ± 612 | 4.68 ± 4.1 | 0.008 ± 0.005 | 0.78 ± 0.66 |
| River fish | 971 ± 395 | 2.2 ± 1.6 | 0.016 ± 0.006 | 0.55 ± 0.48 |
| Salt-water fish | 2316 ± 1450 | 12.9 ± 8.8 | 0.09 ± 0.05 | 0.27 ± 0.2 |
| Shrimps | 6471 ± 1854 | 350 ± 227 | 0.027 ± 0.016 | 0.59 ± 0.32 |
| Squid | 3998 ± 762 | 24.4 ± 9.3 | 0.011 ± 0.01 | 0.12 ± 0.05 |
| Dried milk | 9160 ± 3560 | 56 ± 19 | 0.11 ± 0.08 | <0.02 |
| Milk products | 580 ± 230 | 5.32 ± 2.62 | <0.003 | <0.02 |
| Coffee | 456 ± 388 | 8.83 ± 4.8 | 0.012 ± 0.003 | <0.02 |
| Tea | 938 ± 210 | 6.33 ± 0.15 | 0.035 ± 0.015 | 0.12 ± 0.09 |
| Sugar | 16 ± 3.5 | <0.05 | <0.003 | <0.02 |

## Characteristics of Main Diets

Of the many existing diets in Russia as a result of the undertaken analysis we selected 6 rations. These diets were chosen based on the following criteria:

1) The diet should consist of foods most common and available in these regions;

2) They shall cover the price range of the minimum food basket to the level of income above average;

3) The diet should reflect the nutrition for athletes (sportsmen) and baby food.

**Table 3** shows the structure of typical population diets in the European part of Russia.

1) Daily diet No. 1 [4] [18] [19] corresponds to the minimum subsistence level of the population income. The diet is composed of products with the lowest cost, it has a small variety of foodstuffs and the main food is potatoes, noodles and bread. As for the meat, chicken is mostly consumed and as for the vegetables, cabbage, carrots and beets are consumed.

2) The structure of the diet No. 2 [4] [18] [19] corresponds to the average income level of the population of the region. It is characterized by a larger variety of food, the consumption of bread, potatoes, noodles and cereals decreases, the consumption of meat, fish and seafood, fruits and milk products increases. The total weight of food consumed without fluids in both cases was 1400 g per day.

3) Diet No. 3 is so called "Kremlin" diet [18] [19]. While following this diet, it is advised to avoid sweet, floury, potato dishes, bread, rice, and of course sugar. This diet is characterized by high consumption of pork, beef, chicken and eggs (37%), and milk products. The diet contains fish, seafood and mushrooms in significant amounts. There is absolutely neither bread nor sugar. The average weight of food consumed excluding tea, juices and red wine is 1048 g.

4) In the athletes diet No. 4 [19] [23] is chosen from recommended to athletes experiencing high physical activity. This ration contains a lot of meat, byproducts, game, eggs, potatoes, fruits and milk products. Sugar consumption is even higher than for fish and seafood. The total weight of food consumed without milk, fruit juices and honey is 1835 g.

5) The diet No. 5 was recommended in 2002 for schoolchildren 11 - 17 years old by the Department of the Federal Service for Supervision of Consumer Rights Protection and Human Welfare in Moscow. This diet is characterized by a large proportion of vegetables (20%), fruits (15%), bread and noodles (17%), potatoes (15%), milk products (15%), meat, game and fish (14% all together). The total food weight excluding milk and fruit juices is 2092 g [24].

**Table 3.** The content of foodstuffs in the daily diet, % of total volume.

| Foodstuff/diet No. | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Butter, milk products, cottage cheese, cheese | 4.8 | 10 | 22 | 10 | 23 | 25.7 |
| Meat, meat products | 6 | 7.6 | 13 | 16.3 | 7.6 | 7.7 |
| Game | 5 | 2.2 | 17 | 2.7 | 5.4 | 5.7 |
| Fish, seafood | - | 11 | 11 | 3.7 | 4.6 | 4.8 |
| Hen's eggs | 1.2 | 1.5 | 7 | 1.6 | 1.4 | 1.4 |
| Potatoes | 23 | 14.5 | - | 11 | 14 | 11.2 |
| Vegetables, greens | 15 | 12 | 14 | 21.7 | 14.6 | 14 |
| Fruits | 1 | 12 | 12 | 20.3 | 12 | 12.2 |
| Bread, noodles | 19 | 9.2 | - | 4.3 | 10.5 | 10.4 |
| Cereals, legumes | 20 | 15.5 | - | 2.1 | 3 | 2.9 |
| Pastry, sugar | 4 | 5 | - | 4.9 | 3.5 | 3.6 |
| Tea, coffee | 1 | 1 | - | 0.4 | 0.4 | 0.4 |
| Mushrooms | - | - | 4 | - | - | - |
| Total weight without fluids, g | 1400 | 1400 | 1048 | 1835 | 2092 | 1850 |

6) The diet No. 6 was recommended in 2008 for teenagers over 12 years by the Department of the Federal Service for Supervision of Consumer Rights Protection and Human Welfare in Moscow and the Institute of Hygiene and children and teenagers health protection. This food set is similar to the diet No. 5. The total weight of food consumed without milk and fruit juices is about 1850 g [25].

Of course, the diet of each person (family) is individual; however, provided diets cover almost the entire nutrition range of the Russian population from a minimum set of "food basket" and school nutrition to the athletic and dietary nutrition. Therefore, we can assume that the entire set of currently existing diets can be reduced to six suggested in this paper.

Using the data on the composition and structure of food diets (**Table 2** and **Table 3**) the Cl, Br, I and Se income to the human body was calculated for each of these diets. The results of these calculations and data on the physiologically necessary income (from the literature) are listed in **Table 4**. These data show how many milligrams of Cl, Br, I and Se come to the human body per day for each of the six diets.

It should be mentioned that selenium has a toxic dose of daily intake which is 55 mg/day and it is not exceeded in any of presented diets. The data shown in **Table 4** allow evaluating more or less the real income ($M_r$) of Cl, Br, I and Se compared to physiological needs ($M_{ph}$) of these elements in the human body for different diets. The data in **Table 4** show that the chlorine and iodine income in all diets is lower than physiological needs of the body, and the selenium income is higher. To improve the assessment of the trace elements income to the human body we suggest using the real element income ($M_r$) to the physiological needs ($M_{ph}$) ratio. The result represents a coefficient of the real consumption for a given element ($K_r$), which numerically shows excess or lack of a particular element in the diet in relation to the daily needs for this element.

$$K_r = M_r / M_{ph} \quad (1)$$

Coefficient values $K_r$ calculated by the Formula (1) for Cl, I, and Se are presented in **Table 5**. Since there are currently no evidence-based physiological needs for Br, its coefficient was not calculated.

## 4. Conclusions

The following conclusions based on the analysis above can be drawn:

1) Chlorine income in presented diets is lower or close to the physiologically needed value (it should not be forgotten that a big part of chlorine comes from the drinking water, which is not taken into account in this study);

**Table 4.** The physiologically daily required ($M_{ph}$) and real income ($M_r$) of Cl, Br, I and Se to the human body for different diets.

| Element | Requirement | Income, mg/day ($M_r$) | | | | | |
|---|---|---|---|---|---|---|---|
| | ($M_{ph}$) | Diet 1 | Diet 2 | Diet 3 | Diet 4 | Diet 5 | Diet 6 |
| | mg/day [1]-[8] | | | | | | |
| **Cl** | 3200 | 979 | 1585 | 1920 | 2154 | 2270 | 1713 |
| **Br** | – | 5.54 | 6.49 | 7.1 | 7.5 | 11 | 8.3 |
| **I** | 0.06 - 0.2 | 0.01 | 0.015 | 0.017 | 0.018 | 0.023 | 0.017 |
| **Se** | 0.06 - 0.15 (55) | 0.15 | 0.24 | 0.25 | 0.27 | 0.2 | 0.17 |

**Table 5.** The real Cl, I and Se income coefficient in the human body for various diets.

| Element | $K_r$ | | | | | |
|---|---|---|---|---|---|---|
| | Diet 1 | Diet 2 | Diet 3 | Diet 4 | Diet 5 | Diet 6 |
| **Cl** | 0.3 | 0.5 | 0.6 | 0.7 | 0.7 | 0.5 |
| **I** | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 |
| **Se** | 1.4 | 2.3 | 2.4 | 2.6 | 1.9 | 1.6 |

2) Bromine income with all diets is considerable, but sufficiently lower than the toxic limit (3 g per day);

3) The deficiency of iodine income to the human body in the central regions of the European part of Russia is confirmed. The iodine income in all the diets is of 0.1 - 0.2 of the physiologically needed amount. Improvement of this situation without breaking the natural balance of trace elements income is possible only through consumption of the food artificially enriched with this element (iodized salt, eggs, etc.). It should be taken into account that iodine is a volatile element and almost completely disappears by prolonged heat treatment.

4) The deficient or close to deficient intake of selenium is not confirmed. Income of this element with all enlisted rations is even a little higher than necessary (by factor of 1.4 - 2.6). Therefore, we can state that in any of the above diets, no selenium deficiency is observed and there is no need in measures for increasing selenium income. This should be considered separately, because selenium toxic dose is 55 mg per day, and an overdose can lead to intoxication.

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