Tests of the Iodine Level in Food Supplies of the Population in Central Yakutia

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Abstract. Yakutia is an endemic territory for iodine content in the environment. The region of Central Yakutia belongs to the biogeochemical areas known for iodine deficiency. Goiter etiology is associated with low levels of iodine in food. Thus, we analyzed the iodine content in local raw materials (plants, animals, and natural water) in the biogeochemical areas of Central Yakutia. The obtained results show a low amount of iodine in various water sources (river water, lake water, snow water, and rainwater), even in other areas of Yakutia. The iodine content analysis was carried out in food of local origin (beef, horse meat, milk, potatoes, beets, and carrots) as essential food products. Compared to table values, the lowest iodine level was found in milk (3.3 times lower than the standard rate), vegetables (1.7 times lower), and fish (2 times lower). Satisfying values were registered only in meat. The approximate daily iodine intake of a resident has averaged 65.3 mcg, while the standard input is 130–150 mcg/day.

Keywords: Yakutia · Iodine content · Essential food supplies · Natural water sources

1. Introduction
The main physiological significance of iodine is its participation in the structure and function of the thyroid gland. The thyroid gland plays an essential role in human adaptation to extreme conditions of the north since its hormones are involved in regulating primary metabolism [3]. The essential metabolism of people living in the north has a higher rate than the average value of the primary human metabolism [10]. These metabolic features are associated with the more active production of such hormones as triiodothyronine (T3) and thyroxine (T4) during the adaptation to chronic cold stress [1]. An adequate amount of iodine is required to produce these hormones. The organism is mainly supported by iodine in food. The amount of iodine obtained by the body is also affected by iodine content in natural water sources. The low levels of iodine in natural water contribute to the spread of endemic goiter [5]. When a person has iodine insufficiency (the standard intake for an adult is 130–150mcg.), there are substantial alterations of thyroid gland function, which leads to the development of hyperplasms and goiter. In conditions of iodine insufficiency, the probability of cancer of the thyroid gland increases. The violation of reproductive functions (spontaneous abortion, premature childbirth) is being provoked; the frequency of infant mortality increases. The iodine deficit presents a threat to the intellectual potential of the population in disadvantageous regions [2]. The first scientific evidence that most areas of Yakutia are endemic for iodine deficiency was made in 1963. According to the statistical data, the frequency of congenital hypothyroidism in the Sakha Republic is 1:2700. The problem of liquidation of iodine deficit is defined as a priority in Russia [11]. The problem of iodine deficit requires constant attention to territories with a natural deficiency of microelements.
2. Materials and Methods

Ecosystems of Yakutia are divided into five biogeochemical areas based on differences in their landscape and soil criteria: (1) Kolyma, (2) Verkhoyansk, (3) Central Yakutia, (4) Pri Aldan, and (5) North-Pribaikal. Central Yakutia is located in the Central Lena region. It has a vast territory [6] and borders in the north with the Vilyuysk plateau and in the northeast with the Verkhoyansk ridge (figure 1).

Samples for analysis included such frequently consumed food as meat, milk, and vegetables. They were chosen mainly because they make up the bulk of the diet in the region. The preparation of food samples for chemical analysis had the following stages: cutting large pieces into small portions, homogenizing with a laboratory mixer, weighing the sample at about 0.5–1 g, drying in a muffle furnace with a gradual increase in temperature from 50 to 150 °C for 40 minutes, and reweighing the dried sample. The mineralization of the samples included washing the coal with boiling water. After that, iodine was extracted with chloroform. The iodine content was determined by the photometric rodanide-nitrite method, based on the oxidation of rodanide ions with a mixture of nitrate and nitrite ions [4]. The content of iodine in water was measured by the titrimetric method. Sodium thiosulfate was used as a titrant, whereas starch was an indicator. The iodometric titration must be put in the cold since elevated temperatures cause a loss of iodine due to its evaporation from the solution [7].

The descriptive statistics were calculated using the MS Excel software. The data in the tables are presented in the form M ± m, where M – the mean, m – the error of the mean.

Figure 1. The map of the Republic of Sakha (Yakutia). Source: [9].
3. Results
Table 1 shows that the population of Central Yakutia mainly consumed meat and flour products. The primary vegetable is potatoes. Locals also eat river and lake fish. Dairy products are rare in the diet [11]. For this study, we selected products of local origin (beef, horse meat, milk, potatoes, beets, and carrots) to analyze the iodine content. The samples were taken in different areas of Central Yakutia. The iodine content value did not differ significantly. Thus, we calculated the primary food groups. The content of iodine in the raw materials of primary food groups is shown in table 1.

| Food     | n  | mcg/100g (M±m) | Reference* |
|----------|----|----------------|------------|
| beef     | 25 | 7.6±1.6        | 7.2        |
| horse meat | 25 | 8.5±1.1        | -          |
| fish     | 10 | 72.0±3.6       | 150        |
| milk     | 10 | 2.68±0.7       | 9.0        |
| potatoes | 10 | 3.49±0.6       | 5.0        |
| beets    | 10 | 4.54±0.8       | 8.0        |
| carrots  | 10 | 2.94±0.6       | 5.0        |

Source: [8].

The obtained values of the iodine content in all products are lower than the typical ones in Russia. Drinking water is not the primary source of iodine. It provides only 5–10% of iodine consumption. However, water is an essential source of iodine for vegetables and cereals grown in the region. Therefore, it is closely related to the consumption of iodine in the population. The source of drinking water for most of the population of Central Yakutia is natural water without supplements. In winter, the rural community uses ice from a lake as a source of water. The iodine content in different water sources of Central Yakutia is given in table 2.

The iodine content obtained in various water sources (table 2) shows low values even compared to other areas of Yakutia [6].

| Water source | n  | mcg/liter (M±m) | Min.–Max. |
|--------------|----|-----------------|-----------|
| River water  | 12 | 1.84±0.14       | 1.47–2.24 |
| Lake water   | 25 | 2.38±0.17       | 1.64–3.45 |
| Ice water    | 25 | 0.58±0.05       | 0.35–0.65 |
| Snow water   | 15 | 1.81±0.08       | 0.43–2.41 |
| Rainwater    | 8  | 1.92±0.10       | 0.53–2.21 |

Source: Compiled by the authors.
4. Discussion
We compared the obtained iodine values in products of local origin with the iodine content typical for Russia [8]. A sufficient amount of iodine was found in beef and horse meat, while the values in other products were lower (1.4 times lower in potatoes; 1.7 times lower in carrots and beets). An unexpected low value of iodine was found in milk (3.3 times lower). Moreover, the iodine content in fish was two times lower than expected since we selected not a marine fish, and the local water had low iodine content.

Low iodine content in the ecosystem of this area is the reason for the low content of iodine in raw materials. Thus, the close relationship of the iodine cycle in the components of the biosphere in different territories was proved. According to the map of iodine content in the natural waters of Yakutia compiled by N. N. Sazonov [6], Central Yakutia belongs to the biogeochemical areas with iodine deficiency. The migration of iodine from the more iodine-rich coastal areas to the Arctic regions is prevented by permafrost and low temperatures, which creates a natural deficit.

Storing and cooking food products lead to the loss of iodine. According to the obtained results, there is a significant loss of iodine during the long-term storage of vegetables in winter due to the destruction of iodine by organic compounds. For example, potatoes lost 45.3% of iodine while storing from October to March; beets stored for four months showed a 25.6% decrease in iodine; carrots lost 31.8% of iodine. While storing and drying, iodine loss is caused by the weakly-bound state of cell juice ions. They can easily recover to the elementary conditions and evaporate into liquid.

Low iodine content is observed in ice and snow water compared to different sources of natural water. The low amount of iodine in snow water is explained by a weak iodine cycle between the earth’s surface and atmosphere. For example, in summer, iodine passes from the soil surface into the air at an elevated temperature, increasing the iodine concentration in rainwater. With the onset of low temperatures, this process naturally decreases. The lowest iodine content (1.64 mcg/liter) is found in the lakes fed only by melting ice. It was noted that the deeper the lake, the less iodine is contained in its water. Probably, this can be explained by the slow biogenic process in deep lakes. The iodine content increases with the increase in the content of carbonates in the lake water. The ice water in various geographical areas contains a small amount of iodine (0.40–0.82 mg/l). The population of Central Yakutia has been drinking melted ice water for a long time, which increases the development of the endemic goiter.

Considering the consumption of various food groups in the diet according to statistical data [11], we obtained approximate data on the daily iodine consumption in Central Yakutia. Daily consumption of iodine averages to 65.3 mcg, with standard iodine consumption – 130–150 mcg/day.

5. Conclusion
The research shows that meat contains an appropriate level of iodine. However, all other food of natural origin had a much lower level of iodine than typical values. This fact requires further study using the results of a large number of samples. The obtained results confirm previous data of Central Yakutia, which showed low iodine content in food of natural origin and insufficient consumption of iodine by the population. To calculate accurate daily iodine intake, it is necessary to study the human diet and measure iodine content in the urine. A practical and affordable method to improve iodine support is to add food rich with microelements to the diet, meeting physiological needs.
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