Ecological and physiological feature of some microelements and their concentration in vegetable products

K Sidorova\textsuperscript{1a}, O Dragich\textsuperscript{1,2}, N Shvets\textsuperscript{1b}, A Bukin\textsuperscript{1}, N Ryabova\textsuperscript{2}, E Klyushnikova\textsuperscript{2} and O Kochetova\textsuperscript{3}

\textsuperscript{1}Northern Trans-Urals State Agrarian University, 7, Respubliki St., Tyumen, 625003, Russia
\textsuperscript{2}Tyumen Industrial University, 38, Volodarskogo St., Tyumen, 625000, Russia
\textsuperscript{3}Perm Institute of the Federal Penitentiary Service of Russia, 125, Karpinskogo St., Perm, 614012, Russia

E-mail: \textsuperscript{a}sidorova/clavdija@yandex.ru, \textsuperscript{b}tasha-04-shvets1991@mail.ru

Abstract. In this work, providing human body with essential food components was assessed and the physiological role of chemical elements – iron and manganese – was considered. They are among key nutrients essential for human body. Iron plays an important role in the functioning of immune system; it is necessary for the full functioning of brain and nervous system. Iron deficiency can cause iron deficiency anemia which leads to a slowdown in children’s mental and psychomotor development. Manganese has an effect on the functioning of nervous system; it participates in exchange of impulses between nerve cells and regulated reproductive function of the body. This element promotes insulin secretion and metabolism of fats and carbohydrates, it is necessary for blood formation, metabolism, functioning of musculoskeletal system, immunity, hair growth, normal skin, and is an antioxidant. Microelementoses with metabolic disorders of substances such as iron and manganese can be caused by deficiency, excess or redistribution between the reserve and functional funds of microelements under consideration. Based on this, we can summarize that iron and manganese are indispensable microelements for human body; their deficiency results in undesirable pathological metabolic disorders. Considering the relevance of this problem, the analysis of the content of chemical elements in samples of vegetable crops was carried out. These results a high iron content in beets and potatoes what indicates their nutritional value; sufficient consumption of them covers the daily requirements for manganese and iron.

1. Introduction
Mineral substances are important for human body; first of all, they performs various physiological functions. Being nutritional components they are of great concern for metabolism, biochemical processes, formation and building of bone tissue. Macro- and microelements are necessary to maintain acid-base balance of the body, to create a certain concentration of hydrogen ions in tissues and cells, interstitial and intercellular fluids, as well as to give them osmotic properties that provide normal metabolism [1, 2].

The aim of this research was to substantiate the biological significance of iron and manganese for human body and to establish their level in several vegetable crops.
Balanced diet is a pressing issue, since the most part of our country’s population lack complete protein, as well as the most important vitamins and minerals that have a direct effect on human health.

Currently, many people are faced with the need for increased amounts of iron and manganese. Iron deficiency is experienced by a large number of rural and urban populations, especially women of childbearing age [3, 4, 5]. It is possible to manage such deficiency with the help of iron-containing products of animal or vegetable origin, or with special additives to the diet [2, 6, 7]. Main sources of manganese for humans are food and water.

Iron and manganese are among the key nutrients vital to the human body. Among a large number of microelements, only nine are indispensable, and their imbalance can lead to the onset of clinical symptoms. They also include copper, magnesium, selenium, chromium, iodine, zinc, cobalt (as a component of vitamin B12) and molybdenum [5, 8].

Manganese has an effect, first of all, on the functioning of nervous system, since it directly influences on the exchange of impulses between nerve cells. It regulates reproductive functions, promotes insulin secretion and metabolism of fats and carbohydrates. Manganese is especially required for blood formation, metabolism, functioning of musculoskeletal system, immunity, hair growth, normal skin, and is an antioxidant. In human body, this microelement is concentrated mainly in bones, brain, liver, pancreas and kidneys [2, 6].

Average consumption of manganese for adults is set at 3–5 mg per day (according to different sources), for children this rate is much lower and should be from 0.5 to 2 mg depending on age [5].

Iron is essential for immune system functioning. An organism with iron in sufficient quantity is able to actively fight infectious diseases [1, 9]. In addition, the rate of wound healing depends on iron [2, 7].

Iron content in human body is not very high – about 5 g [5]. Deficiency of this micronutrient is most often associated with its low content in food and lowered absorption in gastrointestinal tract. Iron takes part daily in many physiological processes, therefore, it is necessary to maintain its quantity and regularly replenish it, first of all, through the consumption of foods high in iron.

Iron deficiency can cause iron deficiency anemia which leads to a slowdown in children’s mental and psychomotor development [2]. In addition, iron is necessary for the full functioning of brain and nervous system. Thyroid gland produces its hormones in the required amounts in the presence of this microelement [1].

For a daily balanced diet, one needs to combine products in the right manner. Various elements interacting with each other can both enhance each other’s beneficial effect and neutralize it. Thus, iron is most effectively absorbed in intestine in the presence of vitamins B12 and C, as well as folic and other organic acids [8, 10]. For the same reason, meat dishes are best combined with a side dish of boiled cauliflower or potatoes.

It is unacceptable to take iron with calcium which prevents its proper absorption. A similar effect is caused by tannins and oxalic acid. Iron is hardly absorbed in combination with tea or coffee.

Manganese deficiency leads to depression of nervous system, sleep disturbance and anxiety, dizziness. Consequences of the lack of manganese can also include different problems with fetus development, anemia, inability to exercise reproductive function, growth and development retardation [9, 11]. Iron deficiency increases the risk of developing Alzheimer’s disease, dementia and other diseases caused by impaired brain activity. As a preventive measure, mineral and vitamin supplements can be added to the main sources of iron [10]. Therefore, in order to provide body with the right amount of manganese for its normal functioning, the constant supply of this microelement is necessary. So, its greatest amount is contained in the products of plant origin: cereals, legumes, greens, horticultural crops, vegetables, nuts (Table 1) [1, 5, 12, 13, 14]. Among products of animal origin, meat, liver and kidneys should be noted.
Table 1. Average content of manganese in food.

| Product                           | Manganese in 100 g, mg | Percent of required daily intake, % |
|-----------------------------------|------------------------|------------------------------------|
| Wheat bran                        | 10–15                  | 300–500                            |
| Pine nut                          | 8–10                   | 250–400                            |
| Oat bran                          | 5–7                    | 100–230                            |
| Oats (grain)                      | 5–6                    | 100–200                            |
| 'Hercules' oatmeal flakes         | 3–5                    | 60–100                             |
| Rice (grain)                      | 3–6                    | 60–200                             |
| Walnut                            | 1–3                    | 20–100                             |
| Buckwheat groats (unground)       | 1–3                    | 20–100                             |
| Beans (grain)                     | 1–2                    | 20–65                              |
| Basil (greens)                    | 1–1.5                  | 20–50                              |
| Spinach (greens)                  | Under 1                | Under 35                           |
| Meat (beef, lamb, veal, bacon, poultry, eggs) | 0.5–50 | 10–1670 |
| Fish (salmon, cod, crabs, crayfish) | 0.5–2                | 10–65                              |
| Kidney                            | Under 1                | Under 35                           |

2. Equipment and devices used in studies

When assessing the effects of iron and manganese on human body, it is necessary to learn more precisely about the content of this microelement in certain foods. Therefore, we performed studies to determine the quantitative content of manganese in vegetable crops grown in household plots of the city of Tyumen and Tyumen Region.

Laboratory studies were conducted in the conditions of the Agro biotechnological Center of the Northern Trans-Urals State Agrarian University. According to common methods, samples of root crops grown in household plots of the city of Tyumen and Tyumen Region were taken.

All analyzes were performed in accordance with the procedures established by GOST RF (sampling of vegetables and potatoes according to the Standard SEV 4295–83 and ST SEV 4299–83).

Sample preparation for determining the content of toxic elements was performed using mineralization according to GOST RF 26929–94; GOST RF 31218-2003 (ISO 6498: 1998); GOST RF 32343–2013 (ISO 6869:2000).

The content of toxic elements and heavy metals was defined with the help of ContrAA 300 Atomic Absorption Spectrometer and software package.

Processing of obtained data was performed using Microsoft Excel 2007 for Windows.

3. The results of the study and their discussion

As a result of performed studies, the following data were obtained which are shown in Figure 1. In accordance with obtained data, beets and potatoes have the highest iron content among all crops: 6.7 and 6.2 mg · kg⁻¹, respectively. Onion contains 48% less iron than beets and 2 times less than potatoes. This iron content in beets and potatoes corresponds to 67% and 61% of physiological iron requirements for adults (10 mg · day⁻¹). It is important to remember that not all iron will be absorbed in the body, so it should be supplemented with iron from foods of animal origin.
Figure 1. The content of microelements in vegetable crops, mg kg\(^{-1}\).

In accordance with obtained data, beets and potatoes have the highest iron content among all crops: 6.7 and 6.2 mg\(\cdot\)kg\(^{-1}\), respectively. Onion contains 48\% less iron than beets and 2 times less than potatoes. This iron content in beets and potatoes corresponds to 67\% and 61\% of physiological iron requirements for adults (10 mg\(\cdot\)day\(^{-1}\)). It is important to remember that not all iron will be absorbed in the body, so it should be supplemented with iron from foods of animal origin.

The highest manganese content among studied crops was also found in beets and potatoes and amounted to 1.87 and 1.7 mg\(\cdot\)kg\(^{-1}\) what indicates the accumulating capacity of these crops. Beets contain 40\% higher manganese than carrots and this makes up to 94\% of physiological daily intake of manganese (2 mg\(\cdot\)day\(^{-1}\)).

4. Conclusion

Thus, we can conclude that iron and manganese are indispensable microelements for human body; their insufficient content will result in undesirable pathological metabolic disturbances.

In addition, it should be borne in mind that the Ural Federal District refers to regions with a high content of manganese and iron in soil and water that contributes to their accumulation in plants and animals [5, 10]. Particular attention should be paid to drinking water consumption, since systematic intake of manganese with drinking water in doses exceeding MCL (0.05 mg L\(^{-1}\)) [11] increases mortality rate, especially in children, and provokes complications of pregnancy and childbirth [2, 5]

Based on performed studies, high iron content in beets and potatoes was revealed that indicates the nutritional value of these crops; sufficient consumption of them will result in cover the daily requirements for these microelements. Therefore, the studied vegetables should be included in the diet as an additional source of microelements.

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