Dynamics of zinc content in food products produced in Orenburg region

E V Salnikova¹, T I Burtseva¹, A V Skalniy¹², O I Burlutskaya², O N Kanygina¹

¹Orenburg State University, 13, Pobedy Ave., Orenburg, 460000, Russia.
²Federal Research Centre of Biological Systems and Agro-Technologies of the Russian Academy of Sciences, 29, 9 Yanvarya St., Orenburg, 460000, Russia

E-mail: burtat@yandex.ru

Abstract. The article aims to study the dynamics of zinc content in food products produced in Orenburg region. The studies were conducted in 2011-2015. Zinc content was determined by standard methods in the accredited laboratory of the Testing Center of the All-Russian Scientific Research Institute of Meat Cattle Breeding of the RAS using the atomic absorption spectrometry method. 2100 food samples were tested. Main groups of food products produced in Orenburg region were investigated. Studies have shown that zinc content in wheat bread and fish products is 1.3 times and 1.2 times lower than recommended values. The chronological analysis of zinc content showed that in wheat bread, meat and fish products, its amount increased. The exception is dairy products in which zinc content changes in steps: from 1998 to 2003, zinc content increased from 3.2 to 4.9 mg/kg, and from 2004 to 2015, it decreased from 4.8 to 3.7 mg/kg.

1. Introduction

The amount of information on the role of micronutrient deficiencies is increasing. Clinical and biochemical observations indicate that some diseases (allergies, atherosclerosis, endocrine and cardiovascular, etc.) change the exchange of trace elements.

It is difficult to overestimate the importance of zinc in the human body, since its actions are very diverse [1]. It is known that atherosclerosis is accompanied by a negative balance of zinc. It has been experimentally proven that optimal doses of zinc improve lipoprotein metabolism and normalize the exchange of other trace elements in the human body. For children, the optimal intake of zinc is 4–6 mg/day, and for adults, it is 10–15 mg/day. This rate is fully covered by the intake of water and mixed food. Zinc deficiency can develop with the intake of 1 mg/day or less. The toxicity threshold of this element is 600 mg/day [2]. Due to the high mobility of zinc, the article aims to study the dynamics of changes in its content in basic foods produced in Orenburg region.

2. Materials and methods

Studies were carried out in 2011-2015 in Orenburg region. The zinc content was determined according to standard methods in the accredited laboratory of the Testing Center of the All-Russian Scientific Research Institute of Cattle Breeding of the RAS by atomic absorption spectrometry.

2100 samples were tested:
• wheat bread – 525 samples (GOST 5667-65 "Bread and bakery products");
• dairy products - 525 samples (GOST 3622-68 "Milk and dairy products");
• meat products - 525 samples (GOST 7269-79 "Meat");
• fish products - 525 samples (GOST 7631-85 "Fish and processing products").
The results were processed in MS Excel and STATISTICA 6.1.
The type of distribution of samples was determined using the Shapiro-Wilk criterion. To describe quantitative data having a normal distribution, the arithmetic mean (M), the standard error of the arithmetic mean (m), the minimum (min) and maximum (max) values were used.

3. Discussion of results
The main source of zinc is food. Almost all food products and cereal grains contain zinc in a sufficient and easily digestible form. The biological human need for zinc should be provided by the daily consumption of bread and bakery products. However, recent studies conducted in Orenburg region indicate zinc deficiency in the organisms of surveyed residents [3]. In this regard, we have determined the zinc content in the main groups of food products produced in Orenburg region (Table 1).

Table 1. Zinc content in food groups produced in Orenburg region (mg/kg)

| Indicator          | Wheat bread | Dairy products | Meat products | Fish          |
|--------------------|-------------|----------------|---------------|---------------|
| Medium (M ± m)     | 15.53 ± 0.32| 3.74 ± 0.04    | 31.13 ± 0.46  | 12.47 ± 0.07  |
| Median value (Me)  | 13.2        | 3.7            | 28.5          | 12.4          |
| Minimum (Min)      | 7.97        | 1.54           | 16.00         | 9.13          |
| Maximum (Max)      | 45.60       | 5.83           | 60.69         | 18.88         |
| Number of observations (n) | 525        | 525            | 525           | 525           |
| Reference data     | 21.3        | 4.0            | 32.4          | 15.3          |

According to the results of the study, no sample contained an excessive permissible level (PL). The zinc content in wheat bread is 1.3 times less, and in fish products - 1.2 times less than the recommended standards; although cereals and fish products are main sources of zinc in the human diet. The average zinc content in dairy and meat products is close to the standard values.

The zinc content growth dynamics over the past 20 years (the latest data for 2015 were obtained by the authors) was studied using the results of previous studies [4, 5]. It can be seen that in 1998-2006, there was a slight increase in the zinc content (5.6-8.1 mg/kg) in wheat bread. Since 2011, there was a sharp 1.9-fold increase. In dairy products, the zinc content was unstable: it increased from 3.2 to 4.9 mg/kg (1998-2003) and decreased from from 4.8 to 3.7 mg/kg (2004-2015). In fish products, the zinc content increased from 8.9 to 12.5 mg/kg, i.e. 1.4 times. In meat products, the zinc content increased 1.6 times. This fact can be due to the enrichment of feed with valuable components.

from healthy animals of the same age and breed. The total number of samples taken was n = 75. The average sample of animal bio-substrates (cattle) was formed from internal organs (liver, kidneys, heart). It was found that zinc accumulates in the liver and kidneys (Table 2).

The studies show that the content of zinc in the liver was equal to 99.1 mg/kg. It is the upper limit of the PL. In the kidneys, the zinc content was 87.26 mg/kg with a minimum value of 59.2 mg/kg and a maximum value of 107 mg/kg. We found that the ability of zinc to accumulate in the heart is slightly lower and amounts to 0.7.

The median (Me) of the sample shows the convergence of results for all the samples.
Fig. 1. Changes in the zinc content in products (1998-2015)

We studied the zinc content in the bio-substrates of animals of Orenburg region. Samples were taken

Table 2. Zinc content in bio-substrates (by-products) of animals bred in Orenburg region (mg/kg)

| Indicator     | Liver     | Kidneys   | Heart     |
|---------------|-----------|-----------|-----------|
| Medium (M ± m)| 99.11 ± 0.76 | 87.26 ± 1.25 | 66.19 ± 1.06 |
| Media (Me)    | 98.09     | 86.73     | 67.08     |
| Minimum (Min) | 82.7      | 59.2      | 42.1      |
| Maximum (Max) | 114.5     | 107.3     | 81.2      |
| Number of observations (n) | 75 | 75 | 75 |
| MPC           | 100       | 100       | 100       |

4. Discussion

The compliance of the zinc content in the samples of dairy and meat products with standard values is due to the use of standardized feed in the animal husbandry. The retrospective study confirms our opinion about the feasibility of unified feed. The zinc content is increasing in dairy products due to the internal regulation of zinc metabolism in animals.

The sharp increase in the zinc content in wheat bread (5.63 - 8.1 mg / kg), especially since 2011 (1.9 times), may be due to the change in crops in Orenburg region (Orenburg region portal) and / or the use of modern fertilizers.

The low zinc content in animal bio-substrates can cause zinc deficiency in the human body eating animal meat. Only 40% of zinc is absorbed. Residents living in regions with a low zinc content in animal products are encouraged to eat food products with a high zinc content [6].

Livestock products produced in Orenburg region are environmentally safe in terms of the zinc content.

The relatively high content of zinc in animal products can be an indicator for their use in health, preventive purposes for people with chronic zinc deficiency.

It is known that zinc deficiency causes allergic diseases, hair loss, chronic fatigue, infertility, and impotence [7-10].
5. Acknowledgments
The studies were carried out in accordance with the research plan for 2019–2020 of the Federal Research Center for Biological Systems and Agrotechnology’s of the Russian Academy of Sciences No 0761-2019-0006.

References
[1] Salnikova E V 2016 *The human need for zinc and its sources (review)* 17(4) 11–5
[2] Oberlis D and Skalny A 2015 Pathophysiology of trace elements. Communication 2 Zinc J. of Pathogenesis 13(4) 9–17
[3] Burtseva T I 2019 *Development of technologies of functional and specialized food of animal origin* 240 p
[4] Dunaev V and Boev R 2006 Hygienic assessment of the formation of health risks when exposed to metals and their compounds *Bull. of the Orenburg State University* 12 89–92
[5] Frolova E G 2008 Hygienic assessment of the processes of translocation of metals and their compounds biological human environments from environmental objects in human biological environments: *Abstract of thesis. Dis* (Orenburg: Candhonesciences)
[6] Korotkova A M, Lebedev S V, Kayumov F G and Sizova E A 2017 The influence metal nanoparticles (Fe, Cu, Ni) and their oxides (Fe₃O₄, CuO, NiO) *Agricultural Biology* 52(1) 172–82
[7] Korotkova A, Lebedev S and Gavrish I 2017 The study of mechanisms of biological activity of copper oxide nanoparticle CuO in the test for seedling roots of *Triticum vulgare* *Environ Sci. Pollut. Res.* 24(11) 10220–33
[8] Oberlis D, Harland B and Skalny A 2008 *Biological role of macro-and microelements in humans and animals* (St. Petersburg Science) 273 p
[9] Miroshnikov S, Kharlamov A, Zavyalov O, Frolov A, Bolodurina I, Arapova O and Duskaev G 2015 Method of Sampling Beef Cattle Hair for Assessment of Elemental Profile *Pakistan J. of Nutrition* 14(9) 632–6
[10] Sizova E A, Yausheva E V, Miroshnikov S A, Lebedev S V and Duskaev G K 2015 Element status in rats at intramuscular injection of iron nanoparticles *Biosci. Biotechnol. Res. Asia* 12 119–27