Excessive Copper Levels in Cooked Sausages: A Case Study of Local Market Products

N Fedoseeva¹, V Tetdoev¹, O Sarsembenova²*, E Sepiashvili³, V Gribkova³

¹Department of Animal Science, Production and Processing of Animal Products, Russian State Agrarian Correspondence University, 50 Entuziastov highway, Balashikha, Moscow region, 143907, Russian Federation
²Department of Engineering Ecology and Occupational Safety, Gumarbek Daukeev Almaty, University of Energy and Communication, Almaty, 050000, Kazakhstan
³Faculty of Food Technology and Bioengineering, K.G. Razumovsky Moscow State University of technologies and management (The First Cossack University), 73 Zemlyanoy Val, Moscow, 109004, Russian Federation

Abstract. This study aimed to assess the presence of heavy metals, specifically lead, cadmium, mercury, copper, and zinc in locally sourced sausage products, both cooked and semi-smoked. A total of 30 samples were selected from local markets and subjected to atomic absorption spectrometry for precise metal quantification. Our results indicated that the concentration of zinc (18.36 mg/kg), mercury (0.01 mg/kg), lead (0.24 mg/kg), and cadmium (0.02 mg/kg) in cooked sausage products adhered to the maximum allowable concentration (MAC) guidelines as stated by the TR TS 021/2011 "Hygienic requirements for safety and food value of food products". However, the copper content in cooked sausages was found to be above the MAC at an average of 1.44 mg/kg, suggesting potential food safety concerns. Semi-smoked sausages, on the other hand, had no recorded heavy metal concentrations exceeding the MAC. The findings of this study are significant, underscoring the need for robust and rigorous monitoring of food products for heavy metals, especially copper, to ensure public health and safety.

Keyword. Sausage products, heavy metals, atomic absorption spectrometry, maximum allowable concentration, copper

1 Introduction

For the food industry specialists, those metals that are used in significant volumes in production activities and, as a result of accumulation in the environment, pose a serious danger in terms of their biological activity and toxic properties are of interest [1, 2]. In this regard, cadmium, lead, zinc, and copper pose the most danger, since they exhibit heavily expressed toxicological properties at the lowest concentrations [3, 4, 5].

¹*Corresponding author: oryn23@mail.ru
Potentially dangerous meat toxicants are divided into two large groups. The first group includes substances that enter the animal's body with water and feed. These substances are bound and accumulate in the organs and tissues of animals and poultry and can remain there for a long time [6, 7, 8]. This group of contaminants includes stable inorganic ions of heavy and transition metals, radionuclides, as well as complex organic substances: hormones, antibiotics and pesticides that can not only be retained in meat and meat products for a certain time, but also due to chemical, enzymatic and oxidative reactions turn into structural analogues, many of which are dangerous for the human body [9, 10].

The second group of toxicants includes those chemicals that can be formed in a meat product during technological processing and storage, or be products of microflora. For example, during prolonged storage of meat, meat products and baked fats, lipids can oxidize to peroxides and epoxides. During smoking, carcinogenic substances such as 3,4-benz(a)pyrene and phenol can accumulate in products. Some types of electro physical, microbiological and enzymatic processes can also produce substances with toxic effects: nitrosamines, pyrene, and aflatoxins. This group can also include microorganisms, the presence of which is assessed by microbiological indicators [11, 12].

One important condition for ensuring the safety of meat products is the use of environmentally friendly raw materials produced under conditions that prevent the inclusion of harmful or undesirable components from the environment [13, 14]. For each chemical substance, considering the adverse effects of heavy metals on the human body, the maximum allowable concentration (MAC) is defined. MAC is a science-based maximum concentration of chemical compounds, which in case of daily exposure to a person for a long time or whole life does not cause any diseases or pathological changes in his organism. With the help of maximum allowable concentration the norm of content of various harmful substances in water, in air and in foodstuffs is determined [15, 16].

The purpose of this work is to study the content of heavy metals in sausage products marketed in the city Balashikha, Russia.

2 Materials and method

2.1 Samples

More than 30 sausage batons from different manufacturers were purchased for the study. Sausage products (cooked and semi-smoked sausages) were purchased from different retail outlets in the city of Balashikha (Russia), produced by different manufacturers.

2.2 Determination of heavy metals

Determination of heavy metals was carried out according to GOST 30178 "Raw materials and food products. Atomic-absorption method of determination of toxic elements" on atomic-absorption spectrometer "MGA-915MD" (Russia) [17].

2.3 Statistical analysis

Statistical analysis was performed using Statistica 12.0 (STATISTICA, 2014; StatSoft Inc., Tulsa, OK, USA). The differences between samples were evaluated using ANOVA method.

3 Results
The analysis of the content of heavy metals in cooked sausage products revealed that the concentration of heavy metals (average values) do not exceed the maximum allowable concentrations, except for copper (Table 1). Thus, the average copper content was 1.44 mg/kg, while the maximum allowable concentration was 1.0 mg/kg. The maximum value of copper content was 6.62 mg/kg, the minimum 0.12 mg/kg.

Table 1. Concentration of heavy metals in cooked sausages (n=15), mg/kg

<table>
<thead>
<tr>
<th>Sample</th>
<th>Cu</th>
<th>Zn</th>
<th>Hg</th>
<th>Pb</th>
<th>Cd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean±SD</td>
<td>1.44±0.02</td>
<td>18.36±0.32</td>
<td>0.01±0.001</td>
<td>0.24±0.004</td>
<td>0.02±0.001</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.12</td>
<td>2.11</td>
<td>0.003</td>
<td>0.05</td>
<td>0.002</td>
</tr>
<tr>
<td>Maximum</td>
<td>6.62</td>
<td>40.23</td>
<td>0.04</td>
<td>0.34</td>
<td>0.043</td>
</tr>
<tr>
<td>MAC</td>
<td>1.0</td>
<td>20.0</td>
<td>0.03</td>
<td>0.5</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Table 1. Concentration of heavy metals in cooked sausages (n=15), mg/kg

The closest to MAC (20.0 mg/kg) value was found for zinc (18.36 mg/kg). The analyzed sausage samples also showed a wide range of zinc values: the minimum value was 2.11 mg/kg, the maximum value was 40.23 mg/kg, which is 2 times higher than the maximum allowable concentration of zinc in meat products. For the most toxic metals (mercury, lead and cadmium), the excess of MAC was not detected.

Table 2. Concentration of heavy metals in semi-smoked sausages (n=15), mg/kg

<table>
<thead>
<tr>
<th>Sample</th>
<th>Copper</th>
<th>Zinc</th>
<th>Hg</th>
<th>Pb</th>
<th>Cd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean±SD</td>
<td>0.92</td>
<td>16.49</td>
<td>0.01</td>
<td>0.26</td>
<td>0.02</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.12</td>
<td>3.15</td>
<td>0.001</td>
<td>0.05</td>
<td>0.001</td>
</tr>
<tr>
<td>Maximum</td>
<td>3.21</td>
<td>23.0</td>
<td>0.04</td>
<td>0.40</td>
<td>0.043</td>
</tr>
<tr>
<td>MAC</td>
<td>1</td>
<td>20</td>
<td>0.03</td>
<td>0.5</td>
<td>0.05</td>
</tr>
</tbody>
</table>

In the samples of semi-smoked sausages, the content of heavy metals above the MAC was not detected. The average copper content was 0.92 mg/kg, which is significantly close to the MAC value. Among the samples the maximum copper concentration was 3.21 mg/kg, the minimum - 0.12 mg/kg.

Zinc concentration did not exceed MAC and averaged 16.49 mg/kg. The maximum zinc content was 23.0 mg/kg, the minimum - 3.15 mg/kg.

The most toxic metals (mercury, lead, cadmium) did not exceed MAC, and in general, there were no exceedances of MAC for individual samples either (figure 1).

The presence of heavy metals in permissible concentrations in food does not harm the human body, and for some metals (copper, zinc, etc.) the daily intake of a certain amount of the element is extremely important. For example, the need for copper for adults is 2 mg per day. Copper is necessary for the formation of hemoglobin and in this case cannot be replaced by other elements. Copper is also involved in growth and reproduction. It participates in energy production by processing fats, carbohydrates and proteins. Copper deficiency leads to growth retardation, anemia, dermatosis, depigmentation of hair, partial baldness, loss of appetite, severe emaciation, lowered hemoglobin levels, and atrophy of the
heart muscle. Excess copper leads to deficiency of zinc and molybdenum, as well as manganese [18, 19].

Fig.1. Concentration of heavy metals in sausages

The daily human requirement for zinc is 12-16 mg for adults and 4-6 mg for children. The role of zinc in body life is mainly due to the fact that it is a part of more than 40 important enzymes. They catalyze the hydrolysis of peptides, proteins, some esters and aldehydes. Zinc is involved in carbohydrate metabolism through the zinc-containing hormone insulin. Only in the presence of zinc vitamin A is active. This element is necessary for bone formation. In addition, it shows antiviral and antitoxic effects [20]. Zinc influences taste and sense of smell [21].

Zinc deficiency can be caused by thyroid disorders, liver disease, poor absorption, lack of zinc in water and food, increased requirement during pregnancy, physical exertion, stress, high losses during diarrhea, absorption disorders, hemodialysis, and too much phytin in foods (phytin binds zinc, making it difficult to absorb). Zinc deficiency causes stunting, nervous system overstimulation, and rapid fatigue. Zinc deficiency also leads to infertility. Zinc deficiency can lead to an increased accumulation of iron, copper, cadmium, lead. Excess zinc inhibits growth and impairs bone mineralization. Excess leads to deficiency of iron, copper, cadmium [22].

Excessive cadmium intake into the body can lead to anemia, liver damage, impaired lung function, osteoporosis, skeletal deformities, development of hypertension. It accumulates in the kidneys and can cause the formation of stones in it [23]. Lead, along with arsenic, cadmium, and mercury, is a highly hazardous substance. Cadmium is a very stable heavy metal. The U.S. Environmental Protection Agency has classified it as a probable human carcinogen. Lead accumulates in bones and causes gradual bone deterioration, accumulates in the liver and kidneys, and can cause reduced performance, memory impairment, and even chronic brain disease. Food products can be enriched with lead through contact with materials that contain lead (polymers containing lead impurities; lead seams of tin cans) [24, 25].
Mercury has a toxic effect on the central nervous system, causes tachycardia and leads to emotional instability, memory disorders, insomnia, apathy, etc. The human being constantly feels tired, quickly tires, becomes distracted and irritable. The person is constantly haunted by headaches [26]. The permissible daily dose of mercury for humans is 0.05 mg. In basic foodstuffs, the amount of mercury is regulated at 0.03 mg/kg.

4 Conclusion

The content of substances harmful to human health in meat and meat products is strictly regulated and should not exceed the maximum allowable levels established by hygienic requirements for the quality and safety of food raw materials and food products TR TS 021/2011 "Hygienic requirements for safety and food value of food products".

References


