DETERMINATION OF THE CONTENT OF TOXIC ELEMENTS IN THE TROPHIC CHAIN
«SOIL - PLANT - BEE BODY – HONEY»

ANNOTATION
The article presents the results of a laboratory analysis of the trophic chain: "soil-plant-bee body-honey" for the content of toxic elements such as Pb, Cd, As, Hg and the main organoleptic and physico-chemical indicators of honey. To determine the toxic elements in the trophic chain, sampling was carried out from one experimental site of the Akmola region, Zerendy district, Alekseevka rural district near the largest gold mining company in Kazakhstan "Altyntau Kokshetau". The purpose of the research is to study the level of environmental pollution with toxic elements in the trophic chain: "soil-plant-bee body-honey" and the main organoleptic and physico-chemical indicators of honey. Honey is a natural sugary substance produced by honey bees from the nectar and secretions of plants and insects. The nectar and secretions of the flowers are collected, fermented, matured and stored in the combs of the hives.

According to the results of the study, the lead content in the soil was 0.41 mg/kg. In the plant, the lead index was no more than 0.056 mg/kg. Lead content was not observed in the body of the bee. In bee products, it was not more than 0.03 mg/kg. The content of cadmium in the soil amounted to 0.065 mg/kg, which exceeded the standards for regulatory documentation. In the soil, plant, bee body and beekeeping products, the content of arsenic and mercury was not found. Conducted organoleptic and physico-chemical studies to determine the naturalness and quality of honey. We determined the consistency, aroma, taste, mass fraction of water, mass fraction of reducing sugars, mass fraction of sucrose, diastase number of Goethe units, qualitative reaction to guanosine monophosphate, the presence of mechanical impurities, signs of fermentation.

Key words: soil, plant, bee body, honey, toxic elements, organoleptic indicators.

Introduction. Beekeeping is one of the most waste-free industries. Every year the demand for bee products increases, while the price of honey does not decrease. An important point in the conduct of beekeeping is the possibility of preserving bee families, working in the apiary, each beekeeper can double their number if the correct organization of their work is observed.

Currently, beekeeping is one of the most profitable agricultural industries. The area of Kazakhstan is slightly more than 2.7 million km2, which is 4 times the size of Turkey and the same number of times the size of Ukraine. In terms of the potential of the honey base, our country corresponds to the level of Argentina. Kazakhstan has the necessary wide variety of honey base, necessary for the diversification of production, which creates the necessary prerequisites for the production of high-quality honey, which can successfully compete with the products of other producers. The potential of the honey base of Kazakhstan is huge - it allows you to get 60-90 thousand tons of honey annually [1, 2].

The widespread use of pesticides in agricultural fields has a negative impact on the viability of bees. When treating plants with pesticides, such factors as the method and time of application of pesticides, weather conditions have a great influence. The most dangerous poisoning of bees is slow-acting drugs. Bees bring poisoned nectar and pollen to the hive and mobilize the bee family to collect
them. As a result, the bees and brood die out. Poisons brought into the hive in small quantities may not cause the death of bees, but will adversely affect the development of the colony, its wintering, the susceptibility of bees to diseases, and ultimately reduce the productivity of the colony [3, 4, 5].

The basis of beekeeping is the maintenance of strong bee families in the apiary and obtaining from them as many quality products as possible. One of the urgent tasks of our time is the production of environmentally friendly bee products for humans [6, 7, 8].

There is a growing interest in safe food around the world. Agricultural products produced without the use of chemicals, mineral fertilizers, harmful feed additives are not only about maintaining a clean environment and restoring soil fertility, but also human health [9, 10, 11, 12].

For beekeepers around the world, one of the important problems of the beginning of this century was the reduction of bee colonies. The decline of the bee family was first noted in Europe as early as the 1960s, but has accelerated significantly since 1998. This phenomenon is particularly noticeable in Belgium, France, Germany, Italy, the Netherlands and the UK. In Russia, according to the Institute for Statistical Research and Economics of Knowledge at the Research University Higher School of Economics, the bee population has decreased by 40% in 10 years. If the trend continues, bees could disappear as a species by 2035. This was mainly the result of intensive farming and the use of various plant protection products - herbicides, insecticides, etc. The summer of 2019 was tragic for Russian beekeepers. Bees died en masse in more than 25 regions of the country. Beekeepers call it biological Chernobyl. Taking into account the fact that the bulk of bee colonies are in the households of the population, many families of farmers have lost their income. Experts have not yet established the causes of this collapse. However, even today, many researchers and practitioners believe that this is due to the uncontrolled use of chemicals for the treatment of crops such as rapeseed, and the lack of information from beekeepers about the processing time [13, 14, 15, 16].

Currently, the agricultural sector of Kazakhstan faces the strategic task of increasing the production of high-quality food products, among which honey is of particular importance as a valuable therapeutic and dietary ingredient with preventive properties. An average of 20,000 tons of honey is produced annually in Kazakhstan.

According to S. Tereshchenko, President of the Kazakh National Union of Beekeepers "Bal Ara", East Kazakhstan is one of the leading countries in the production of beekeeping products. Currently, it supplies about 2,500 tons of marketable honey, which is mainly sold in Kazakhstan [17, 18].

Research work to determine the content of toxic elements in the trophic chain "soil - plant - bee body - honey" as an indicator of environmental pollution in the conditions of the Akmola region was not carried out.

The purpose of the research is to study the level of environmental pollution with toxic elements in the trophic chain: "soil-plant-bee body-honey" and the main organoleptic and physico-chemical indicators of honey.

Research objectives:
- to analyze the level of content of toxic elements in the trophic chain: "soil - plant - bee body - honey";
- to determine the main organoleptic and physico-chemical indicators of honey.

Honey is a natural sugary substance produced by honey bees from the nectar and secretions of plants and insects. The nectar and secretions of the flowers are collected, fermented, matured and stored in the combs of the hives.

Natural honey can be floral, dew honey or mixed. Honey is classified as monofloral, that is, this honey was obtained from one plant, or polyfloral, that is, honey obtained from several plant species. Honeydew honey is formed when bees process sweet secretions from the stems and leaves of plants (honeydew) and sweet secretions of insects (honeydew), and mixed honey consists of a natural mixture of flower and honeydew honey. However, the presence of honeydew honey is undesirable in the diet of bees and unacceptable in winter.

Environmental pollution directly or indirectly affects the vital activity of animals and insects, including bees, respectively, and bee products. In this regard, there is a need to study bee products for compliance with quality indicators, for the absence of toxic elements. Honey quality control is carried out by analyzing insoluble substances, pollen, moisture, minerals, sugars, hydroxymethyl fural, aromatic and toxic substances, acidity, electrical conductivity and diastase activity [19, 20].

**Materials and research methods.** The research work was carried out within the framework of the intra-university competition of young researchers of the Sh. Ualikhanov Kokshetau University. "Youth
and Science" under the project "Obtaining high-quality honey from honey bees of different breed groups", 2022-2023

The analyses were carried out in laboratories:

1. Scientific and Production Enterprise "ANTIGEN" LLP, Almaty region, Karasai district, Abai village, (certificate of accreditation no. KZ.T.04.0183);
2. Akmola branch of JSC "National Center for Expertise and Certification" (certificate of accreditation No. KZ.T.03.0428).

Soil analysis for the content of toxic elements (lead, cadmium, arsenic, mercury) was carried out according to ST RK 2.377–2015 (MP KZ 07.00.034422016).

The analysis of the plant for the content of toxic elements (lead, cadmium, arsenic, mercury) was carried out according to State Standard 26932-86, State Standard 26933-86, State Standard 26930-86, State Standard 26927-86, respectively.

The analysis of the bee body for the content of toxic elements (lead, cadmium, arsenic, zinc) was carried out according to State Standard R 52097-2003, State Standard 30178-96, respectively. The analysis of organoleptic and physico-chemical characteristics of honey was also carried out. As a result of a laboratory study of honey, the following indicators were studied: appearance (consistency), aroma, taste according to State Standard 19792-2017; mass fraction of water in %, according to State Standard 31774-2012; mass fraction of reducing sugars, mass fraction of sucrose in % according to State Standard 32167-2013; diastase number, Goethe units, qualitative reaction to guanosine monophosphate, mechanical impurities, signs of fermentation according to State Standard 19792-2017.

According to safety indicators, honey was tested for the content of toxic elements, mg/kg: lead, cadmium, arsenic according to State Standard 26929-94.

The sunflower research fields where the sampling was carried out were located near the largest gold mining company in Kazakhstan, the Altyntau Kokshetau Mining and Processing Plant. Samples for the determination of toxic elements in the trophic chain were taken from one experimental site of the Akmola region, Zerendy district, Alekseevka rural district.

**Results and discussion.** We conducted studies to assess the content of toxic elements in the trophic chain «soil – plant - bee body – honey» to determine environmental pollution and studied the main organoleptic and physico-chemical parameters of honey.

According to the results of the study given in Table 1, the lead content in the soil was 0.41 mg/kg. In the plant, the lead index was no more than 0.056 mg/kg. There was no lead content in the bee's body. In bee products, it was no more than 0.03 mg/kg. At the same time, the lead content in the studied variants did not exceed the permissible norm.

<table>
<thead>
<tr>
<th>№</th>
<th>Toxic elements: mg/kg, no more</th>
<th>Soil</th>
<th>Plant</th>
<th>Bee body</th>
<th>Honey</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pb 32,0</td>
<td>0,41</td>
<td>1,0</td>
<td>0,056</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Cd -</td>
<td>0,065</td>
<td>0,1</td>
<td>0,047</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>As 2,0</td>
<td>0</td>
<td>0,3</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Hg 2,1</td>
<td>0</td>
<td>0,05</td>
<td>0</td>
<td>-</td>
</tr>
</tbody>
</table>

In the sunflower plant it was 0.047 mg/kg. No cadmium content was observed in the bee's body. In bee products (honey), the cadmium content was 0.017 mg/kg. At the same time, the cadmium content in the studied variants did not exceed the maximum permissible norm.
The cadmium content in the soil was 0.065 mg/kg, which exceeded the norms according to regulatory documentation. The content of arsenic and mercury was not detected in the soil, plant, bee body and bee products.

Honey as a natural animal and vegetable product has no equal in the spectrum of ash elements, although their quantitative content in honey is insignificant. About 40 macro- and microelements were found in it, but the set of them in different honey is different. Honey contains a lot of potassium, phosphorus, calcium, chlorine, sulfur, magnesium; copper, manganese, iodine, zinc, aluminum, cobalt, nickel, etc. are found among the main trace elements. Honey of normal composition contains no more than 0.6% ash, while in fall honey this indicator can rise to 1%. The quantitative and qualitative composition of the ash residue of honey can provide valuable information about the origin of honey. The mineral content of honey significantly decreases with the addition of glucose, sucrose, sugar syrup, artificial inverted sugar and sugar honey. The ash content of these counterfeits is below 0.1%. Thus, honey quality control is carried out by measuring a whole range of indicators and is an important and urgent problem of modern beekeeping [18].

In our work, organoleptic and physico-chemical studies were carried out to determine the naturalness and quality of honey. At the same time, the consistency, aroma, taste, mass fraction of water, mass fraction of reducing sugars, mass fraction of sucrose, diastase number of Goethe units, qualitative reaction to guanosine monophosphate, presence of mechanical impurities, signs of fermentation were determined (Table 2).

Table 2 – Organoleptic parameters of honey

<table>
<thead>
<tr>
<th>№</th>
<th>Name of Indicators</th>
<th>Standards for Regulatory Documents</th>
<th>The actual value of the indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Appearance (consistency)</td>
<td>Liquid, partially or completely crystallized</td>
<td>respond</td>
</tr>
<tr>
<td>2</td>
<td>Smell</td>
<td>Pleasant, from weak to strong, odorless</td>
<td>Pleasant, odorless</td>
</tr>
<tr>
<td>3</td>
<td>Taste</td>
<td>Sweet, pleasant, without foreign taste</td>
<td>Sweet, pleasant, without foreign taste</td>
</tr>
<tr>
<td>4</td>
<td>Qualitative response to guanosine monophosphate</td>
<td>negative</td>
<td>negative</td>
</tr>
<tr>
<td>5</td>
<td>Mechanical impurities</td>
<td>Not allowed</td>
<td>Not detected</td>
</tr>
<tr>
<td>6</td>
<td>Signs of fermentation</td>
<td>Not allowed</td>
<td>Not detected</td>
</tr>
</tbody>
</table>

According to Table 2, honey according to organoleptic indicators corresponds to RD standards. The appearance of honey is liquid, partially crystallized. It has a pleasant aroma without foreign odors. Honey tastes sweet, pleasant, without foreign taste. Mechanical impurities in the composition of honey were not detected. Signs of fermentation in honey are also not found.
The diastase number is the main indicator of the naturalness and maturity of honey. The higher this indicator, the better the honey. The diastase number of natural and benign honey is in the range from 3 to 50. Diastase activity is expressed by a diastase number. The diastase number is the number of milliliters of 1% soluble starch, which is decomposed in one hour by amylolytic enzymes contained in one gram of anhydrous honey substance. One milliliter of starch solution corresponds to one unit of activity. The diastase enzyme is sensitive to heating, which makes it possible to use the diastase number of honey as an indicator of its heat treatment. The diastase activity of honey begins to decrease already when it is heated to 40-50 °C, and when heated to 60 °C and above, the destruction of the enzyme accelerates, with the formation of oxymethylfurfural, which can also be determined by laboratory studies.

Summer in the northern regions is short, plants bloom for only 1015 days, but the nectar is so fragrant that bees will not fly by, and honey is made of high quality, which belongs to rare, high-grade honey. Northern honey is not only a food product, but also a therapeutic agent [21].

In our research, the diastase number of Gote units was 15. The water content was no more than 18%. The content of reducing sugars exceeded the norms of RD and amounted to 87%. The sucrose content was 3.0%. The diastase number of Goethe units is 15. The qualitative reaction to guanosine monophosphate is negative, that is, there are no technological violations during the production and sale of honey (Figure 1).

**Conclusions.** Thus, when assessing the trophic chain "soil – plant - bee - honey body" to determine environmental pollution, no excess concentration of toxic elements was found.

According to organoleptic and physico-chemical studies, honey complies with RD standards, which indicates the naturalness and quality of honey.

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**REFERENCES**


секрецияларын жинау, содан кейін тазарту арқылы бал шығарады. Бұл тазарту жеке аралардың ішінде де, регургитация мен ферментативті бельсенділік арқылы да, улыда сақтау кезінде де, балдың қанттарын қою және тұтқыр болғанша шоғырландыратын суды булуға мүмкіндік береді.

Зерттеу нәтижелері бойынша топырақтағы қорғасын мөлшері 0,41 мг/кг құрады. Осімдікте қорғасын мөлшері 0,056 мг/кг аспады. Ара денесінде қорғасын мөлшері байкалады. Ара шаруашылығы өнімдерінде, 0,03 мг/кг аспады. Топырақтағы кадмий мөлшері 0,065 мг/кг құрады, бұл нормативті құжаттағы бойынша нормдан ашып түсті. Топырақта, осімдікте, ара денесінде және Ара өнімдерінде мышьяк, сынап анықталмады. Балдың табиғалық мен сапасын анықтау үшін органолептикалық және физика-химиялық зерттеулер жүргізілді. Біз консистенция, нәсіл, дәм, судың массалық үлесі, қанттардың массалық үлесі, сахарозаның массалық үлесі, Го́тэ бірліктерінің диастаздық санын, ГМФ-ға сапалы реакциясы, механикалық коспалардың болуын, ашыту белгілерін анықтады.

РЕЗЮМЕ

В статье приведены результаты лабораторного анализа трофической цепи: «почва–растение–тело пчелы–мед» на содержание токсичных элементов, таких как Pb, Cd, As, Hg и основных органолептических и физико-химических показателей меда. Для определения токсичных элементов в трофической цепи отбор проб проводился с одного опытного участка Акмолинской области, Зерендинского района, сельского округа Алексеевка вблизи самой крупной золотодобывающей компании в Казахстане «Алтынтау Кокшетау». Целью исследований является изучение уровня загрязнения окружающей среды токсичными элементами в трофической цепи: «почва–растение–тело пчелы–мед» и основных органолептических и физико-химических показателей меда. Мед-сладкое и вяжущее вещество, производимое пчелами, наиболее известными из которых являются медоносные пчелы. Мед производится и хранится для питания пчелиных семей. Пчелы производят мед, собирая, а затем очищая сахарный секрет растений или секрет других насекомых, таких как мед тлей. Эта очистка происходит как внутри отдельных пчел, так и за счет срывания и ферментативной активности, а также при хранении в улье, путем испарения воды, которая концентрирует медовый сахар, пока они не станут густыми и вязкими.

По результатам исследования содержание свинца в почве составило 0,41 мг/кг. В растении показатель свинца составил не более 0,056 мг/кг. В теле пчелы содержание свинца не наблюдалось. В продуктах пчеловодства составил не более 0,03 мг/кг. Содержание кадмия в почве составило 0,065 мг/кг, что превысил нормы по нормативной документации. В почве, растении, теле пчелы и продуктах пчеловодства содержание мышьяка, ртути не обнаружено. Проведены органолептические и физико-химические исследования для определения натуральности и качества меда. Нами определены консистенция, аромат, вкус, массовая доля воды, массовая доля редуцирующих сахаров, массовая доля сахарозы, диаэзное число единиц Готе, качественная реакция на ГМФ, наличие механических примесей, признаки брожения.