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QUALITY PARAMETERS OF BEE HONEY PRODUCED IN THE REPUBLIC OF MOLDOVA AND THE EUROPEAN UNION

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Abstract. Bee honey remains one of the most popular domestic animal products exported to the European Union. Honey producers should ensure the safety of the product by providing evidence of its safety through traceability. This research has been carried out to assess the quality and harmlessness of domestic and imported honey based on the organoleptic, physicochemical parameters and toxic metals. The honey samples were analyzed at the Public Institution Republican Center for Veterinary Diagnosis in the Laboratory of Food Products Testing. The results of organoleptic analysis and the values of evaluated indices (mass fraction of water:16,4-17,8%; acidity index: 0,9-3,3 milliequivalents per 100 g of honey; hydroxymethylfurfural content: 4,7-25,8%; sucrose: 1,3-2,0%; toxic elements; lead: < 0,02 mg/kg) revealed that the investigated domestic and imported honey samples meet the established standards and are recommended for human consumption.

Key words: *Honey; Physicochemical composition; Hydroxymethylfurfural content; Toxic elements.*

Rezumat. Mierea de albine rămâne a fi un produs destul de solicitat și unul din produsele de origine animalieră din țară care este exportat în Uniunea Europeană. Producătorii trebuie să asigure inofensivitatea produsului, prezentând dovezi privind siguranța alimentului prin trasabilitatea acestuia. Cercetările au fost efectuate cu scopul aprecierii calității și inofensivității mierii de albine autohtone și de import în baza indicilor organoleptici, fizico-chimici și a metalelor toxice. Mostrele de miere au fost analizate la Instituția Publică Centrul Republican de Diagnostic Veterinar în Laboratorul de Încercări ale Produselor Alimentare. Rezultatele analizei organoleptice și valorile indicilor evaluați (fracția masică de umiditate: 16,4-17,8%; indicele acidității: 0,9-3,3 miliechivalenți la 100 g de miere; conținutul de hidroximetilfurfural: 4,7-25,8%; zaharoză: 1,3-2,0%; plumb: < 0,02 mg/kg) au demonstrat, că mierea din Republica Moldova și de import studiată corespunde normelor stabilite și se recomandă pentru consumul uman.

Cuvinte-cheie: *Miere; Compoziție chimică; Conținut de hidroximetilfurfural; Elemente toxice.*

INTRODUCTION

The beekeeping sector is an integral part of agriculture and it is one of the main or additional sources of income for some citizens.

Considering that 84% of Europe's plant species and 76% of its food production depend directly or indirectly on bee pollination, the importance of this sector is far greater than its contribution to the gross economic output.

The most pressing current issue is still the detection of counterfeit honey on the domestic market, which caused honey prices drop by half, especially in intensive honey-producing countries such as Romania, Bulgaria, Spain, Portugal, France, Croatia and Hungary.

Honey is the third most counterfeited product in the world, therefore it is essential not only to protect beekeepers, but also to fight for consumer protection and human health.

Counterfeiting is a phenomenon that affects almost all imported honey, especially honey originating from China. According to statistics, China produces 450,000 tons of honey annually, which exceeds the overall production of the world's largest producers: the EU, Argentina, Mexico, the United States and Canada (Comisia pentru Agricultură și Dezvoltare Rurală, 2018).

In recent years, honey production in Moldova has grown slowly, without major fluctuations, registering values ranging between 2.8 to 5.2 thousand tons per year.

The annual production of honey and other bee products strongly relies on the weather conditions, and in case of unfavorable conditions (heavy and excessive rainfall, low temperatures above -30° C, strong and persistent winds, etc.), they have an impact on the number of worker bees and the amount of nectar secreted by flowers, which inevitably leads to a decrease in production.

Moldovan honey has a fructose/glucose ratio of 1.1 to 1.12, which exceeds the parameters of honey produced in European countries and other honey-exporting countries. Moldovan honey has low acidity content and a specific aroma generated by the spontaneous flora.

At the same time, the overall honey export is distributed among several exporters who have found access to the European or international markets. The honey, mostly generated by the spontaneous flora – mixed or polyphorous, is usually packed in 300 kg containers.

Up to 15% of the total amount of the honey produced in Moldova is consumed locally, and the remaining 85% of the production is exported.

The main sales market of our country is the European Union, where more than 90% of our honey is exported, in 2015 it was 98%. The main importers of domestic honey are Italy, Germany, France and Slovakia, but there are also smaller but still important markets such as Romania, Poland and Denmark (Chișlea, 2018).

In order to reach maximum exploitation and use of honey, our country should present a „residue monitoring mechanism" by conducting analyses for residues of antibiotics, sulfonamides, pesticides and heavy metals, as defined in the Sanitary-Veterinary Norms on the surveillance and control measures of some substances and their residues in live animals and their products, as well as residues of veterinary drugs in products of animal origin, approved by Government Decision no. 298 dated April 27, 2011 harmonized with the provisions of Council Directive no. 96/23/CE of April 29, 1996, regarding the measures to monitor certain substances and their residues in live animals and products of animal origin (Council Directive 2001/110/EK). However, the experts in this field highlight the problems related to the existing laboratory certification and preliminary testing up to the export stage.

Local honey is of high quality due to the glucose/fructose ratio, but its prices are not competitive compared to the main competitors - Ukraine, China and Argentina. For Moldova, the possibilities of market access are great, especially in terms of selling high-quality honey, including eco honey (HG nr 768, 2020).

Moldovan honey is highly appreciated by Western buyers and is also exported to the European market due to its naturalness. Nevertheless, Moldovan honey importers [request authentic analyses of naturalness and glyphosate from local exporters.

Bee honey remains a highly sought-after product exported to the European Union.

At the same time, to access the European Union market, the honey producer should ensure the harmlessness of the product, presenting evidence of food safety through its traceability.

Depending on the raw material used by bees to produce honey, there are only two types of honey: floral honey and manna honey, GD no. 815/2020.

The purpose of this research was to study the quality and harmlessness of local and imported bee honey based on the organoleptic, physicochemical indices and toxic element concentrations.

MATERIALS AND METHODS

The quality and safety of bee products can be achieved by implementing a food safety management system along the food chain, based on the principles of Hazard Analysis and Critical Control Points (HACCP), in accordance with the provisions of Law no. 296/2017, concerning general product hygiene requirements.

The evaluation of the sensory properties of food plays an important role in determining the authenticity of products, especially when comparing reference products, classification and standardization, establishing freshness and harder-to-perceive defects (Bulancea, 2002).

The assessment of quality parameters in food safety, the way of presenting, marking and labeling is carried out by the manufacturer, including the sensory and physicochemical indices determined for each batch according to the established rules and methods of analysis (Banu, 2002).

When honey is heated, some of the fructose is converted to hydroxymethylfurfural (HMF), this similar phenomenon can occur when honey is stored at the wrong temperature for a longer period (Lenco, 2003).

Honey is divided into two categories according to its commercial quality and organoleptic indices (taste) (Bologa, 2001).

- superior quality - A (acacia, lime, etc.);
- lower quality - B (buckwheat, Calluna vulgaris, etc.).

Honey subject to commercialization must comply with the quality standards according to the rules in force.

Natural honey, including imported honey, can be introduced on the domestic market only if it meets the basic requirements stipulated in the Technical Regulation (HG nr 815, 2020).

Figure 1. *Honey samples prepared for analysis*

Since honey is one of the products exported to the EU in compliance with the EU regulations regarding the import requirements for products of animal origin, the actuality of the topic addressed consists in evaluating the quality of domestic honey and comparing it with imported honey.

Honey produced in the Republic of Moldova and honey imported from Germany was used as biological material for this study.

Honey samples were submitted for analysis to P.I. The Republican Veterinary Diagnostic Center in the Food Products Testing Laboratory, where organoleptic, physicochemical indices and the toxic element concentrations in bee honey were determined.

The sampling and determination of the quality and safety characteristics of bee products were carried out in accordance with the approved Regulation on the application of testing methods and the interpretation of results in the sanitary-veterinary field, (HG nr 941, 2010), and the Rules on the methods of sampling and analysis of samples to control official level of lead, cadmium, mercury, inorganic tin, 3- MCPD and polycyclic aromatic hydrocarbons in food products, approved by the Government Decision nr 661, 2007.

The principles of organoleptic analysis of bee honey were determined according to the indications given in STAS 784/3 – 1989.

RESULTS AND DISCUSSIONS

Honey samples were evaluated according to the following organoleptic indices: appearance, color, consistency, taste and aroma.

According to the appearance, the honey from the analyzed samples is clean, homogeneous, and without impurities and foam.

The color of the analyzed honey varied from pale yellow in sample 2 to brownish-brown in sample 3.

Honey aroma/odor is imprinted by the essential oils presented in the floral nectar, therefore the studied honey has a pleasant, well-pronounced floral aroma.

The taste of the honey is pleasant and sweet.

The consistency was appreciated by the way the honey flows from a glass stick or a wooden spatula, expressing the respective level: watery, fluid-thin, fluid-viscous, sticky and crystallized. The honey exhibited for appreciation had the consistency of fluid-thin samples 1-3, fine crystals - sample 2 and partially crystallized - sample 4.

Generally, honey contains a variable percentage of water, approx. 17% and dry substances 83%, of which sugars constitute 80% and 20% represent minerals, vitamins, enzymes, and pollens (Mateescu et al., 2011; Neikovchena et al., 2019; Красочко & Еремия, 2022).

According to data from the specialized literature, the predominant carbohydrates in honey are fructose (38.2%) and glucose (31.3%), which are monosaccharides that can be easily absorbed by the body. Other carbohydrates present in honey are: maltose (7.3% in nectar honey), which is a disaccharide composed of two glucose molecules, sucrose (max. 5% in nectar honey) is a disaccharide composed of one molecule of glucose and one fructose.

Honey is made up mostly of carbohydrates and water and, in addition to these constituents, there are also small amounts of other organic substances and mineral salts.

Water content in honey characterizes its degree of maturation and quality, therefore the preservation and crystallization of honey depends on its water content.

When the nectar contains less than 20% water, the bees naturally absorb it, thus indicating the signal that the product can be extracted. The main requirements for storing honey are the optimal temperature of 10-120C and humidity of 60%. Honey is stored for a long period at a humidity of approx. 100%, will get an increase in water content of up to 50%.

The results of the conducted research demonstrated that in the examined honey, the mass fraction of water varied between 16.4-17.8%, on average constituting 16.90%, thus falling within the normative requirements, Table 1.

Table 1. *Mass fraction of moisture in honey*

Biological material	Obtained results,%	Normative requirements, max., %	Testing method
Honey, sample 1	16,7	20,0-21,0	PS7.2-L-FCh-07
Honey, sample 2	17,8		
Honey, sample 3	16,7		
Honey, sample 4	16,4		
Average	16,900±0,308		

Figure 2 shows the data of the average content of water and dry matter in the studied honey.

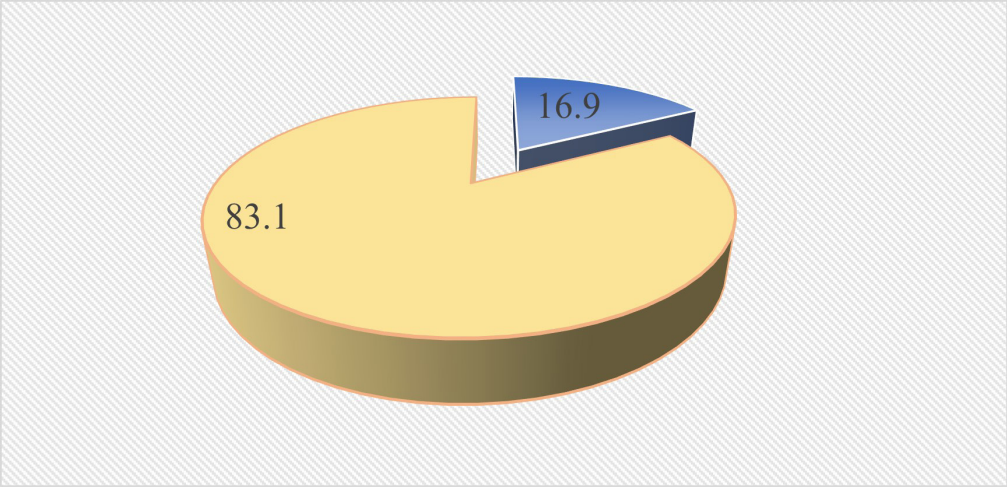

Figure 2. *The average content of water and dry matter in the studied honey, %*

The average dry matter was 83.1%, and the moisture fraction -16.90%, thus falling within the normative requirements.

The content of mineral substances in honey varies according to its botanical and geographical origin. These mineral elements can be generated both by natural (soil, plants) and by anthropogenic sources.

The potential pollutants with Pb, Zn, Cd and Cu, Cr, Ni are considered to be from the air, and the soil, with Fe and Mn (HG nr 298, 2011).

The results of the study of the presence of heavy metals in bee honey are shown in Table 2.

As a result of carrying out research to detect toxic element concentrations, it was demonstrated that in the studied honey they do not exceed the maximum admissible limits, with an average presence of lead < 0.02 mg/kg.

Table 2. *Toxic element concentrations in honey (Pb)*

Biological material	Obtained results, mg/kg	Normative requirements, max., mg/kg	Testing method
Honey, sample 1	0,02	0,1	SM SR EN 14083:2006 PS 7.2-L-R-22
Honey, sample 2	<0,02		
Honey, sample 3	<0,02		
Honey, sample 4	<0,02		
Average	<0,02±0,0		

Another quality parameter of honey is its acidity, which helps to appreciate the level of freshness of honey. Honey acidity can naturally increase when it „ages" or when it is extracted from propolis combs or it is damaged by fermentation.

According to the normative requirements, the acidity of honey should not exceed the maximum of 4.0-5.0 milliequivalents per 100 g of product (Table 3).

Table 3. *The acidity of honey*

Biological material	Obtained results, milliequivalents per 100 g	Normative requirements, max., milliequivalents per 100 g	Testing method
Honey, sample 1	1,8	4,0-5,0	PS7.2-L-FCh-07
Honey, sample 2	0,9		
Honey, sample 3	2,0		
Honey, sample 4	3,3		
Average	2,000±0,495		

Thus, the studied honey recorded acidity indices ranging between 0.9 - 3.3 milliequivalents per 100 g of honey, on average constituting 2.00 milliequivalents per 100 g, which falls within the normative requirements.

Honey sweetened with sugar syrup has very low acidity, while honey sweetened with invert sugar has high acidity.

The acidity of honey can vary greatly; the existing regulations regarding honey provide only the maximum limit for acidity that can be determined by titration.

Also, another indicator parameter of honey quality is the content of hydroxymethylfurfural, a product obtained by partial decomposition or substitution (falsification) with fructose. Honey contains significant amounts of fructose. In acidic or hot environments, it decomposes forming furfural acids, the most prominent of which is hydroxymethylfurfural.

In freshly extracted honey, hydroxymethylfurfural can be found in tiny amounts or traces, but its concentration depends on the conditions and temperature of honey storage and preservation. When honey is stored at temperatures below 200C, very little fructose breaks down, which reduces the amount of hydroxymethylfurfural.

Usually, the amount of hydroxymethylfurfural is 0.1-0.2 mg/100 g (1-2%) in the first months after honey extraction and 1.5 mg/100 g (15%) when stored at room temperature for 1- 2 years, these values are regulated by the State Standard 784/1989 for all types of honey. The liquefaction process at high temperatures significantly increases the hydroxymethylfurfural levels, reaching the value of 10 mg/100 g.

Hydroxymethylfurfural levels of up to 20 mg/100 g are allowed for polyflora honey, and this value is accepted both by the State Standard 784/1989 and by FAO/WHO regulations.

When honey is overheated, fructose is partially transformed into hydroxymethylfurfural. The same phenomenon can occur when honey is stored for a long time at high temperatures. Freshly harvested honey that has not been heated contains virtually no hydroxymethylfurfural.

The hydroxymethylfurfural levelsin the examined samples are shown in Table 4.

Table 4. *Hydroxymethylfurfural levels*

Biological material	Obtained results, %	Normative requirements, max., %	Testing method
Honey, sample 1	20,4	20,0 (40,0 just for the honey in the jar)	PS7.2-L-FCh-07
Honey, sample 2	4,7		
Honey, sample 3	25,8		
Honey, sample 4	17,2		
Average	17,025±4,475		

Thus, the honey examined for the hydroxymethylfurfural levels fell within the recommended norms according to the normative requirements ranging between 4.7 - 25.8%, on average being 17.025%, a higher indicator being recorded by the imported honey, which proves the fact that this honey has been processed to keep it in liquid form.

The dry matter of honey is made up of sugars - 80%, mainly glucose and fructose. Sucrose is an important component of honey. Natural honey has a sucrose content of up to 10%, and when introducing different types of sugar, the sucrose level exceeds these values. These sugars are formed by enzymatic inversion of sucrose.

The sucrose content in the studied samples is presented in Table 5.

Table 5. *Sucrose content*

Biological material	Obtained results, %	Normative requirements, max., %	Testing method
Honey, sample 1	2,0	5,0-10,0	PS7.2-L-FCh-07
Honey, sample 2	1,6		
Honey, sample 3	1,7		
Honey, sample 4	1,3		
Average	1,650±0,144		

The content of sucrose in the studied honey samples varied between 1.3 - 2.0%, on average being 1.65%, thus falling within the limits of the normative requirements of up to 10%.

Therefore, we can state with certainty that both the honey produced in the Republic of Moldova and the studied samples of imported honey correspond to the norms established according to the organoleptic, physicochemical properties and potentially toxic element concentrations, being recommended for human consumption.

CONCLUSIONS

As a result of evaluating the bee honey samples taken in the study, it was found out the following:

1. *organoleptic indices:*
- appearance - the honey from the analyzed samples is clean, homogeneous, without impurities and foam;
- color - varied from pale yellow in sample 2 to brownish-brown in sample 3, which corresponds to the range of colors for bee honey;
- aroma - the studied honey has a pleasant, well-pronounced floral aroma;
- taste - sweet, pleasant;
- consistency - fluid-thin, fluid-viscous, sticky and crystallized falling within the existing requirements for honey.

2. *physicochemical parameters*:
- on average, the physicochemical parameters fell within the recommended norms: mass fraction of water - 16.90%; acidity indicators - 2.00 milliequivalents per 100 g; hydroxymethylfurfural content - 17.025%, with variations between 4.7 - 25.8%; sucrose -1.65%, which correspond to the normative requirements regulated by the EU standards and directives.

3. *toxic element concentrations:*
- the toxic element concentrations in the studied honey do not exceed the maximum admissible limits; it was found out that lead concentration was on average < 0.02 mg/kg.

It is recommended to consume natural, unprocessed honey, and to take into consideration that storing and preserving honey in inappropriate temperature and humidity conditions leads to an increase in the level of moisture and hydroxymethylfurfural content.

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