PHYSICAL AND CHEMICAL INDICATORS, CONTENT OF MICRO AND MACROELEMENTS AND HEAVY METALS IN SUNFLOWER HONEY

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Abstract

The problems of production of high-quality and safe food products and food raw materials are now quite relevant and widely discussed all over the world. The purpose of this work was to study the physicochemical parameters, the content of micro-, macroelements and the presence of heavy metals in sunflower honey. The content of micro- and macroelements and the presence of toxic elements in sunflower honey were determined by the atomic absorption spectrometry method at the Institute of Chemistry of the ASM. It is revealed that the mass fraction of water in sunflower honey has made 17.12%, a invert sugar – 92.24%, sucrose – 1.35%, Diastase number – 21.49 units to Gotha, oxymethylfurfural – 9.44 mg/kg, the general acidity – 2.26 cm^{3}NaOH solution in (miliequivalent) on 100 g of honey and ash-content – 0.12%. It is revealed that in sunflower honey minerals average Mn – 0.320 mg/kg, Zn – 0.397 mg/kg, Cu – 0.397 mg/kg, Fe – 2.950 mg/kg, Cr – <0.12 mg/kg, Ni – <0.17 mg/kg, and macroelements: Ca^{2+} – 85.833 mg/kg, Mg^{2+} – 27.00 mg/kg, K^{+} – 944.23 mg/kg, Na^{+} – 23.00 mg/kg, P_2O_5 – 67.20 mg/kg. It is established that sunflower honey on average contains 1.101 mg / g of amino acids, of which the greatest amount is proline – 27.52%, aspartic acid – 15.44% and glutamic acid – 11.35% of the total amount. It is established that sunflower honey on average contains heavy metals: lead – <0.10 mg/kg, cadmium – <0.01 mg/kg, strontium – <2.3 Bq/kg, zinc – 0.448 mg/kg, copper – 0.318 mg/kg. The mineral structure of honey can depend on the region of origin of melliferous cultures, including on soil and climatic conditions.

Keywords: sunflower honey, physical and chemical indicators, micro, macroelements, heavy metals, amino acids

INTRODUCTION

At present, the problems of production of high-quality and safe food products and alimentary raw materials are widely discussed in the world. Under bad environmental conditions affected by heavy industrial pollution, the production of high-quality, safe and organic beekeeping products is becoming increasingly problematic.

The quality of honey products greatly depends on the environmental health. Often the beekeepers set up the bee yards close to industrial companies and public roads, which negatively affects the environmental parameters of the beekeeping products.

Nectar bearing capacity of both sunflower and other entomophilous plants, is largely determined not only by meteorological conditions, but also by varietal features. Hybrid varieties have a number of characteristics of development and bloom. The entire field usually starts blooming and the blooming period lasts more than two weeks, but insect-pollinators mainly visit those flowers bloomed early and this pollination period lasts for five-seven, ten days maximum. Maximal weight of the observation hive (8.2 kg) was observed on the 4th of July [3].

Climatic influences on pollen production, nectar producing and visiting of the plants by bees are different and multivarious. Bee pollination affects the plants much more than some agricultural methods. To improve the sunflower yields it is necessary not only to guarantee ideal bee pollination, but also to choose for the sowing the regions with suitable combination of meteorologic factors [2].

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Sunflower honey is golden, when honey crystallizes it becomes a light amber, sometimes with a greenish. Sunflower honey has a tart flavor with a faint aroma; it contains large quantities of vitamin A and has antibacterial properties. From 1-hectare of blooming sunflower the bees produce 50 kg of honey [6].

Heavy metal contamination of air, soil, water and plants is a serious problem which affects living organisms, crop productivity and quality of food too.

It was determined that the honey collected from the territories close to transport routes contains heavy metals such as radionuclidesofcaesium-137 and strontium-90. Honey collected from the fields located far from main roads contains radionuclides and heavy metals in much smaller amount [4].

Highly toxic heavy metals are accumulated in soil, plants are transferred through trophic chains and pose a serious threat both to people and honey bees [5].

The objective of this paper is to investigate physical and chemical indicators, the content of micro- and macroelements, and presence of heavy metals in sunflower honey.

MATERIALS AND METHODS OF INVESTIGATION

The study is based on analyses of the honey samples collected from diverse regions as well as provided by economic agents to the National Veterinarian Laboratory, where the physical and their chemical properties were analyzed.

The content of water, invert sugar and sucrose, diastase number, oxymethylfurfural and the general acidity in honey samples were tested according to general standards.

Ash-content and insoluble substances in water, the content of grains, gelatin, starch in honey were determined according to the sanitary-and-veterinary examination.

The content of micro-and macroelements and the presence of toxic substances in the acacia honey were defined by the atomic absorption spectrometry method at the Institute of Chemistry(Academy of Sciences of Moldova).

The results achieved were processed by methods of variation statistics and using computer software.

RESEARCH RESULTS

Among agricultural plants cultivated on large areas and advantageous for beekeeping is the sunflower as a source of nectar and pollen that blooms in the second half of June for thirty (30) days and its hybrids bloom from 10-to 20 days.

The sunflower cluster blooms for 10 days, one single flower blooms for 24-36 hours. Bee productivity per one hectare of sowing is from 30 to 120 kg(on average 60 kg) depending on climatic conditions and agronomic practices. Under good weather conditions a bee-family collects 0.5-5.0 kg, up to 9 kg nectar per day [1].

The sunflower in Republic of Moldova is grown for 5 years average, covering 223910.6 hectares, ranging from 193301 hectares in 2010 to 252912 hectares in 2014 (Table 1).

In recent years there has been an increase of areas planted with sunflower up to 30.8% compared to2010.

In the northern zone of Moldova the sunflower sowings cover 95492.8 hectares or 42.65%,in the south zone 76810.2 hectares or 34.30% and in the central zone – 51607.6 hectares or 23.05%.

Table 1 Planted sunflower areas in Republic of Moldova

Years	Acreage, ha (hectare)
2010	193301
2011	212140
2012	228460
2013	232740
2014	252912
Five-year average	**223910.6**

The studies for five years (2008-2012) revealed that total amount of sunflower honey from all analyzed honey lots made 3360 kg, ranging from 150-to 1260 kg.

It is revealed that the mass fraction of water in sunflower honey has made on average17.12%, ranging from 15.5 up to 20.0%; the mass fraction of invert sugar – 92.24% (87.7-96.0%); sucrose – 1.35% (1.00-1.98%); diastase number – 21.49 Gotha units (15.2-30.69 Gotha units) (Table 2).

Table 2 The average content and physicochemical properties of sunflower honey (2008-2012)

Indicators	Admissible quantity	$\overline{X} \pm S\overline{x}$	V, %	Limits (min.-max.)
Total amount of honey of all analyzed lots, kg	-	3360	-	150-1260
The mass fraction of water, %	max. 20.0	17.12±0.818	10.68	15.5-20.0
The mass fraction of invert sugar, %	min. 65.0	92.24±1.635	3.96	87.7-96.0
The mass fraction of sucrose, %	max. 8.0	1.35±0.220	36.25	1.0-1.98
diastase number, Gotha units	min. 8.0	21.49±2.738	28.49	15.2-30.69
The content of oxymethylfurfural, mg/kg	max. 20.0	9.44±4.023	95.25	1.9-19.3
The general acidity, $cm^3$of NaOH solution in (miliequivalent) on 100 g honey	max. 4.0	2.26±0.308	30.47	1.3-3.15
Ash content, %	max. 0.5	0.34±0.179	-	0.06-0.8
Insoluble substances in water, %	max. 0.2	not found	-	not found
Grains	not found	not found	-	not found
Gelatin	not found	not found	-	not found
Starch	not found	not found	-	not found

The content of oxymethylfurfural was on average 9.44 mg/kg with limits from 1.9 to 19.3 mg/kg, the general acidity–2.26 cm^3NaOH solution in (miliequivalent) on 100 g of honey (1.3-3.15 cm^3 NaOH solution per 100 g of honey), ash-content–0.34% (0.06-0.8%). Insoluble substances in water, grains, gelatin, starch were not found in sunflower honey.

It is revealed that total number of analyzed micro-elements in sunflower honey is on average 4.354 mg/g, ranging from 3.63 to 5.29 mg/kg (Table 3).

Table 3 Average content and limits of micro-elements in sunflower honey (2015-2017), mg/kg

Indicators	$\overline{X} \pm S\overline{x}$	V, %	Limits (min.-max.)
Manganese (Mn)	0.320 ± 0.140	75.84	<0.12 – 0.59
Zinc (Zn)	0.397 ± 0.084	36.56	0.25 – 0.54
Copper (Cu)	0.397 ± 0.105	45.82	<0.25 – 0.60
Ferrum (Fe)	2.950 ± 0.165	9.69	2.72 – 3.27
Chrome (Cr)	<0.12 ± 0.0	0	<0.12
Nickel (Ni)	<0.17 ± 0.0	0	<0.17
Total amount	**4.354**	**-**	**3.63 – 5.29**
Ash, %	0.125 ± 0.035	39.59	0.09 – 0.16

It is determined that amount of manganese (Mn) is 0.320 mg/kg (<0.12 – 0.59 mg/kg), zinc (Zn) and copper (Cu) – 0.397 mg/kg, ferrum (Fe) – 2.950 mg/kg, chrome (Cr) – <0.12 mg/kg, nickel (Ni)–<0.17 mg/kg, ash –0.125%.

Total number of analyzed macroelements in sunflower honey is on average 1147.23 mg/kg ranging from 946.3 to 1365.2 mg/kg (Table 4).

Table 4 Average content and limits of macroelements in sunflower honey (2015-2017), mg/kg

Indicators	$\overline{X} \pm S\overline{x}$	V, %	Limits (min.-max.)
Calcium(Ca^{2+})	85.83 ± 9.181	18.53	67.7 – 97.4
Magnesium(Mg^{2+})	27.00 ± 1.670	10.71	24.9 – 30.3
Potassium(K^{+})	944.23 ± 93.553	17.16	787.5 – 1111.1
Sodium(Na^{+})	23.00 ± 6.935	52.22	13.2 – 36.4
Phosphates(P_2O_5)	67.20 ± 11.514	29.68	53.0 – 90.0
Total amount	**1147.263**	**-**	**946.3 – 1365.2**

The sunflower honey contains mostly Potassium (K^+)– on average 644.23 mg/kg (787.5-1111.1 mg/kg), the amount of calcium (Ca^{2+}) is 85.83 mg/kg (67.7-97.4 mg/kg), and the amount of Phosphates (P_2O_5) is – 67.20 mg/kg (53.0-90.0 mg/kg).

The amount of Magnesium (Mg^{2+}) and Sodium (Na^+) is the lowest: Mg^{2+} – 27.0 mg/kg; Na^+ – 23.0 mg/kg. The coefficient of variation ranged from 10.71% to 52.22%. The total amount of heavy metals in sunflower honey is– 0.887 mg/kg; of which lead – <0.10 mg/kg, cadmium – <0.01 mg/kg, zinc – 0.380 mg/kg, copper - 0.397 mg/kg (Table 5).

Table 5 Average content and limits of heavy metals in sunflower honey(2015-2017)

Indicators	Admissible quantity	Average quantity
Lead (Pb), mg/kg	max. 1.0	<0.10
Cadmium (Cd),mg/kg	max. 0.05	<0.01
Zinc (Zn), mg/kg	-	0.380 ± 0.070
Copper (Cu), mg/kg	-	0.397± 0.070
Total amount	**-**	**0.887**
Strontium (Sr) Bq/kg	max. 80.0	<2.3

The amount of found strontium (Sr) is <2.3 Bq/kg, whilst the maximum allowed quantity is 80.0 Bq/kg.

It is established that sunflower honey on average contains 1.101 mg/g of amino acids, of which free amino acids– 0.706 mg/g, irreplaceable amino acids – 0.653 mg/g and replaceable amino acids – 0.272 mg/g. The predominant amino acid in honey is proline 27.52% as well as aspartic acid – 15.44%, glutamic acid – 11.35% of the total amount.

CONCLUSIONS

1. It is revealed that the mass fraction of water in sunflower honey has made on average17.12%; the mass fraction of invert sugar - 92.24%;sucrose - 1.35%; diastase number - 21.49Gotha unit; oxymethylfurfural - 9.44 mg/kg; the general acidity - 2.26 cm^3NaOH solution in (miliequivalent) on 100g of honey and ash-content - 0.39%.

2. It is revealed that the average amount of microelements in sunflower honey is Mn – 0.320 mg/kg, Zn and Cu – 0.397 mg/kg, Fe – 2.950 mg/kg, Cr – <0.12 mg/kg, Ni – <0.17 mg/kg, and macroelements: Ca^{2+} – 85.833 mg/kg, Mg^{2+} – 27.00 mg/kg, K^+ – 944.23 mg/kg, Na^+ – 23.00 mg/kg, P_2O_5 – 67.20 mg/kg.

3. It is determined that sunflower honey on average contains heavy metals: lead – <0.10 mg/kg, cadmium – <0.01 mg/kg, strontium – <2.3 Bq/kg, zinc and copper– 0.397 mg/kg.

4. The mineral structure of honey can depend on the region of origin of melliferous cultures, including on soil and climatic conditions.

5. It is revealed that sunflower honey on average contains 1.101 mg/g of amino acids, of which free amino acids– 0.706 mg/g, irreplaceable amino acids – 0.653 mg/g and replaceable amino acids – 0.272 mg/g. The predominant amino acid in honey is proline 27.52% as well as aspartic acid – 15.44%, glutamic acid – 11.35% of the total amount.

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