COMPLIANCE OF BEE PRODUCTS PICKING LAVENDER AND SAGE, REGARDING PESTICIDE RESIDUES

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Abstract

The aim of this research was to evaluate the compliance of pesticide residues in bee products (pollen, honey) collected from lavender and sage plantations. The researches were carried out on bee families being harvested in the lavender (Ungheni district) and sage (Glodeni district) plantations, from which samples of bee products were taken (lump pollen and portions of honeycombs with honey) from 5 families of bees from each collection. The pollen and honey samples taken were tested in an accredited Laboratory for the content of pesticide residues more common in our country. The results of the research demonstrated that, in the pollen and honey samples, taken from the bee families located at the lavender picking, no detectable concentrations of residues of any of the 63 pesticides were detected (Acetamipirid, Chlothianidin, Imidacloprid, Thiacloprid, Tiametoxam, Bifentrin, Ciflutrin, Cipermetrin, Deltametrin, Fenvalerat, Lambda-Ghalotrin, Tau-fluvalinat, Clorpirifos, Endosulfan, HCH izomeri, Diazinon, Diclorvos, Dimetoat, Ethion, Fenitrotion, Fosalon, Malation, Permetrin, Pirimitos-metil, Protenotos, Fenixicarb, Fipronil, Indoxacarb, Pirinicarb, Azoxistrobin, Bitertanol, Bromuconazol, Ciproconazol, Difenoconazol, Diniconazol, Epoxiconazol, Flutriafol, Penconazol, Picoxistrobin, Propiconazol, Tebuconazol, Tiadimeton, Boscalid, Kresoxim-metil, Benzanton, Captan NIM, Ciprodinil, Clorotalonil, Dimetomorf, Folpet NM, Iprodion, Procimidon, Spiroxamină, Vindozolin, Pirimetanil, Haloxifop, Glifosat, Pendimetalin, Prometrin, Trifluralin, Lufenuron, Piridaben, Propargit). In the pollen and honey samples, taken from the bee families located at the sage harvest, no detectable concentrations of residues of any of the 63 tested pesticides were detected. Therefore, it was concluded that the bee products (pollen and honey), obtained from the bee families located at the lavender and sage harvests in the researched fields, are ecologically clean (bio) in terms of the content of pesticide residues, and the sites respectively of lavender and sage are suitable for the practice of organic beekeeping.

***Key words**: pollen, honey, lavender, sage, residues, pesticides*

INTRODUCTION

In the Republic of Moldova, there are approximately 182 thousand bee families, from which approximately 4.5 - 5.7 thousand tons of honey are obtained annually, of which approximately 4000 tons are exported to different countries [1]. Other bee products, quite important, are obtained from bees, such as: wax, pollen, propolis, royal jelly, venom, which are used in various fields of the national economy (food industry, medicine, pharmaceuticals, cosmetics, plastic arts, etc.).

According to a European Parliament News [16], bees pollinate crops and wild plants, helping to support biodiversity and ensure food security. No fewer than 84% of plant species and 76% of food production in Europe depend on bee pollination. This represents an economic value estimated at around 14.2 billion euros per year. In our country, bees pollinate about 600,000 ha of land with different agricultural crops, from which an additional 20-30% of the harvest is obtained with an annual value of over 1.6-2.0 billion lei [1].

Along with the increase in the standard of living, ecological agri-food production is increasingly demanded in the European

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community. The conditions for obtaining ecological agro-food production are provided in detail in Regulation (EEC) no. 2092/91 of the EU Council of 24 June 1991 regarding the ecological agricultural production method and its indication on agricultural and food products [18].

Based on this Regulation, Law no. 115 of 09.06.2005 regarding organic agri-food production [12] in which the basic principles of the regulation of organic agri-food production are stipulated. In order to implement the provisions of this Law, the Government adopted Decision no. 149 of 10.02.2006 for the implementation of the Law on organic agri-food production [5] and Decision 567/2014 by which it approved the National Program for monitoring pesticide residues and the content of nitrates in food products of vegetable origin for the years 2015-2020 [6].

At the same time, the mass implementation of ecological agro-food production is quite difficult, first of all, due to the large-scale application of pesticides in agriculture, which not only pollute bee products, but also endanger the health of bees.

Based on the synthesis analysis of some bibliographic sources, regarding the contamination of propolis with pesticide residues, Tincu S. et al. [19] state that pesticides induce oxidative stress, causing the generation of free radicals and altering the enzymatic system for the elimination of antioxidants or oxygen free radicals. The antioxidant effect of administered unpolluted propolis is greater than in the case of the simultaneous use of propolis and chlorpyrifos, thus proving the reduction of the antioxidant effect of propolis due to the presence of the insecticide. According to a study by researchers from the University of Neuchâtel in Switzerland [4], over 70% (3 out of 4) of honey samples collected from around the globe contain at least one type of neonicotinoid, a pesticide used in agriculture conventional.

This is the conclusion expressed by the researchers, who wanted to know how many of the five types of neonicotinoids tested are in the nearly 200 samples of honey collected from around the globe. The study was published in the journal Sciencenews. At least one of the 5 types of neonicotinoids tested (*acetamiprid, clothianidin, imidacloprid, thiacloprid* and *thiamethoxam*) was found in 75% of the analyzed samples. In 45% of these, two or more types of pesticides were discovered, while in 10% of the samples, the specialists detected four or five types of pesticides. "*On a global scale, the contamination is really worrying. Pesticides are used on many types of agricultural crops in different climates. We found traces of pesticides in honey collected from remote islands with very little developed agriculture,*" study co-author Edward Mitchell, a biologist at Neuchâtel University in Switzerland, told sciencenews.org.

In the Republic of Moldova, according to the information of Capitanu D. [2], *"over 2.0 thousand tons of pesticides are used annually. The average value of the intensity of use of phytosanitary products is 1.6 kg/ha, but in some areas of the country there is an increased intensity - about 4.6 kg/ha. According to further research, neonicotinoid substances are absorbed by plants in the soil and contaminate their pollen and nectar. Neonicotinoids act on bees as neurotoxic substances, which leads to the loss of the bees' sense of orientation, which can no longer safely return to the hive."* In these conditions, to practice organic beekeeping, beekeepers are always looking for areas with a clean ecological environment, which are increasingly rare, especially in areas with intensive agriculture.

In this context, the aim of this research was to evaluate the compliance of pesticide residues in bee products (pollen, honey) collected from lavender and sage plantations.

MATERIALS AND METHODS

The researches were carried out on bee families being harvested in the lavender (Ungheni district) and sage (Glodeni district) plantations, from which samples of bee

products were taken (lump pollen and portions of honeycombs with honey) from 5 families of bees from each collection. In total, 20 samples of biological material (pollen, honey) were taken. Each sample of biological material collected had a weight of 100 - 150g. The samples taken were packed in plastic bags and transported the same day to the accredited laboratory of Î.S. "Center for Applied Metrology and Certification", in accordance with the sanitary-veterinary norms regarding the methodology of sampling, processing, packaging and transport of samples intended for laboratory examinations [14]. Each sample of biological material taken was tested for the content of pesticide residues (63 names) more common in our country (Tab. 1).

Table 1 Names of pesticides tested for residue content in bee products

No d/o	Pesticide name and pesticide group	No d/o	Pesticide name and pesticide group	No d/o	Pesticide name and pesticide group
Neonicotinoid insecticides		22	*Malation*	44	*Kresoxim-metil*
1	*Acetamipirid*	23	*Permetrin*	45	*Benzanton*
2	*Chlothianidin*	24	*Pirimitos-metil*	**Dicarboximide fungicides**	
3	*Imidacloprid*	25	*Protenotos*	46	*Captan NIM*
4	*Thiacloprid*	**Carboximide insecticides**		47	*Ciprodinil*
5	*Tiametoxam*	26	*Fenixicarb*	48	*Clorotalonil*
Pyrethroid insecticides		27	*Fipronil*	49	*Dimetomorf*
6	*Bifentrin*	28	*Indoxacarb*	50	*Folpet NM*
7	*Ciflutrin*	29	*Pirinicarb*	51	*Iprodion*
8	*Cipermetrin*	**Triazole fungicides**		52	*Procimidon*
9	*Deltametrin*	30	*Azoxistrobin*	53	*Spiroxamină*
10	*Fenvalerat*	31	*Bitertanol*	54	*Vindozolin*
11	*Lambda-Ghalotrin*	32	*Bromuconazol*	55	*Pirimetanil*
12	*Tau-fluvalinat*	33	*Ciproconazol*	**Herbicides**	
Organochlorinated insecticides		34	*Difenoconazol*	56	*Haloxifop*
13	*Clorpirifos*	35	*Diniconazol*	57	*Glifosat*
14	*Endosulfan*	36	*Epoxiconazol*	58	*Pendimetalin*
15	*HCH izomeri*	37	*Flutriafol*	59	*Prometrin*
Organophosphorus insecticides		38	*Penconazol*	60	*Trifluralin*
16	*Diazinon*	39	*Picoxistrobin*		**Acaricides**
17	*Diclorvos*	40	*Propiconazol*	61	*Lufenuron*
18	*Dimetoat*	41	*Tebuconazol*	62	*Piridaben*
19	*Ethion*	42	*Tiadimeton*	63	*Propargit*
20	*Fenitrotion*	**Carboximide fungicides**			
21	*Fosalon*	43	*Boscalid*		

The tests were carried out by the methods of gas chromatography - mass spectrometry (GC-MS) and liquid chromatography - mass spectrometry (LC-MS), described in the Collection of SM standard methods [11]. Since no pesticide residues were detected in any of the analyzed samples, it was not possible to compare the obtained data with the norms of the maximum permissible limits (MLA), according to the Sanitary Regulation regarding the maximum permissible limits of residues of phytosanitary products from/or on food products and food of vegetable and animal origin for animals, approved by the Decision of the Government of the Republic of Moldova no. 1191 of 23.12.2010 [17], adjusted to EU norms.

Based on the results obtained, conclusions were made regarding the compliance of beekeeping products (pollen, honey) with regard to pesticide residues both for their placement on the domestic market and for exporting, including the European Union markets.

RESULTS AND DISCUSSIONS

Pesticide residue content in pollen and honey collected from lavender field. The

pollen and honey obtained from the bee families located at the lavender picking, have exceptionally good properties due to the content of essential oils and particularly valuable biologically active substances. According to some information [13], lavender pollen acts favorably on the stomach and in cases of loss of appetite, and lavender honey has miraculous properties. Among them are: the unmistakably pleasant smell, the tonic and diuretic effect, the relief of the symptoms of rheumatism and lung diseases, the antiseptic action, the calming effect, the antibacterial, antifungal, antiviral, antioxidant, anticonvulsant, antispasmodic properties, the reduction of blood sugar levels. Lavender honey is used to sweeten hot drinks and cookie dough. Other beneficial properties of lavender pollen and honey can be found in folk medicine.

In this context, the assessment of the conformity of the bee products obtained from bee families placed for harvesting at the lavender plantations, regarding the content of pesticide residues, for the production of organic bee products, is particularly important. The results of this assessment are presented in the table below (Tab. 2).

Table 2 Content of pesticide residues in lavender pollen and honey, mg/kg

Name of the pesticide group	The results on each test				
	1	2	3	4	5
In the pollen of cycads					
Neonicotinoid insecticides (5 pesticides)	n.d.*	n.d.	n.d.	n.d.	n.d.
Pyrethroid insecticides (7 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Organochlorine insecticides (3 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Organophosphorus insecticides (10 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Carboximide insecticides (4 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Triazole fungicides (13 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Carboximide fungicides (3 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Dicarboximide fungicides (10 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Herbicides (5 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Acaricides (3 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
In honey					
Neonicotinoid insecticides (5 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Pyrethroid insecticides (7 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Organochlorine insecticides (3 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Organophosphorus insecticides (10 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Carboximide insecticides (4 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Triazole fungicides (13 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Carboximide fungicides (3 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Dicarboximide fungicides (10 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Herbicides (5 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Acaricides (3 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.

Remark: n.d. – not detectable*

The results of the laboratory tests of the 5 pollen samples and 5 honey samples, taken from the families of bees located at the lavender picking, demonstrated that in none of the samples was any concentration of residues of any pesticide from the 63 tried.

We would like to mention that, in the course of the research, a wide spectrum of pesticides were tested, including the main groups of phytosanitary products, used in agriculture to treat agricultural crops (including industrial multi-year plantations), such as: neonicotinoid insecticides, pyrethroid insecticides, organochlorine insecticides, organophosphorus insecticides, carboximide insecticides, triazole fungicides, carboximide fungicides, dicarboximide fungicides, herbicides and acaricides.

The lack of detectable concentrations of pesticide residues in the pollen and honey samples obtained from the bee families located at the lavender picking was on the one hand predictable, because in a previous research of ours [3], no pesticide residues

were detected in lavender flowers. On the other hand, the lack of pesticide residues in the samples of these bee products could not be guaranteed to be predictable because the soils, in which this perennial hetero-oleaginous plant was cultivated, were treated in not long ago with various pesticides to combat pests and weeds.

Judging by the results of the content of pesticide residues in lavender pollen and honey, we can say that the pesticides we researched, over time, decompose, and their residual concentrations in agricultural soils have decreased essentially and are no longer found in the final bee production.

Therefore, based on the results of the research carried out, we can conclude that the bee products, especially the pollen and honey, obtained from the bee families located at the lavender picking site in the field researched by us, are ecologically clean (bio) in terms of the content of residues of pesticides, and the respective lavender site is compliant for the practice of organic beekeeping.

Pesticide residue content in pollen and honey collected from sagebrush. Common sage (Salvia officinalis) is a perennial ether-oleaginous plant from which a very valuable essential oil is obtained for the perfume and shampoo industry. At the same time, this plant is widely used in cooking, as an ornament, as well as in medicine for the treatment of cardiovascular diseases [7].

Sage pollen is a valuable food product, it is diuretic, tonic, sedative, anaphrodisiac, regulates menstruation, as well as digestive and intestinal functions [8].

Sage honey has a delicate aroma and a pleasant taste, with important therapeutic properties: anti-inflammatory, recuperative, antibacterial, hemostatic and diuretic. This bee product regulates hormonal activity and stimulates the endocrine system, is an excellent nerve tonic, soothes sore throats and dry coughs, stimulates vascular and cardiac activity [7].

Resulting from the extremely valuable biological, food and therapeutic properties of bee products (pollen, honey) obtained from sage flowers, the results of their conformity assessment, regarding the content of pesticide residues, for the practice of organic beekeeping and the production of organic bee products, are quite current (Tab. 3).

Table 3 Content of pesticide residues in sage pollen and honey, mg/kg

Name of the pesticide group	The results on each test				
	1	2	3	4	5
In the pollen of cycads					
Neonicotinoid insecticides (5 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Pyrethroid insecticides (7 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Organochlorine insecticides (3 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Organophosphorus insecticides (10 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Carboximide insecticides (4 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Triazole fungicides (13 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Carboximide fungicides (3 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Dicarboximide fungicides (10 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Herbicides (5 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Acaricides (3 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
In honey					
Neonicotinoid insecticides (5 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Pyrethroid insecticides (7 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Organochlorine insecticides (3 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Organophosphorus insecticides (10 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Carboximide insecticides (4 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Triazole fungicides (13 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Carboximide fungicides (3 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Dicarboximide fungicides (10 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Herbicides (5 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.
Acaricides (3 pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.

The results of the laboratory tests of the 5 pollen and honey samples, taken from the families of bees located at the picking of sage flowers, demonstrated that in none of the samples were detectable concentrations of residues of any pesticide from the 63 tested. We can also mention that, in the course of the research, a wide spectrum of pesticides were tried, which includes the main groups of phytosanitary products used in agriculture for the treatment of agricultural crops, including some industrial multi-year plantations. These groups of pesticides include: neonicotinoid insecticides, pyrethroid insecticides, organochlorine insecticides, organo-phosphorus insecticides, carboximide insecticides, triazole fungicides, carboximide fungicides, dicarboximide fungicides, herbicides and acaricides.

Even in the pollen and honey samples obtained from the bee families located at the sage picking, the lack of detectable concentrations of pesticide residues was not predictable, because special research of sage flowers for the content of pesticide residues was not carried out, and the soils, in which this perennial hetero-oleaginous plant was cultivated, were treated in previous years, repeatedly, with different pesticides to combat pests and weeds.

Based on the results of laboratory tests on the content of pesticide residues in sage pollen and honey, we can state that the residual concentrations of pesticides in the agricultural soil cultivated with sage have decreased essentially and no longer present any danger for the contamination of beekeeping production.

Therefore, based on the results of the research carried out, we can conclude that the beekeeping products, in particular, the pollen and honey obtained from the families of bees located at the sage picking site in the field we researched, are ecologically clean (bio), in terms of the residue content of pesticides, and the respective sage site is compliant for the practice of organic beekeeping.

Generalizing the results of these researches, we can mention that the conclusions related to the evaluation of pesticide residues in bee products obtained in different sites refer only to the conformity of those concrete fields (sites) with agricultural crops that were researched by us, as well as to bee products (pollen, honey) obtained from the flowers of plants grown in those fields (sites) investigated.

It is regrettable that the conclusions of our research regarding the suitability of some ranges (sites) and agricultural crops for the practice of organic beekeeping cannot be extended in general to all ranges (sites) and similar crops in the country, such as the land of perennial hetero-oleaginous crops (lavender, sage), because the research was carried out on a single plot of the same plant.

In order to draw general systematized conclusions, which could be extended to all lands (sites) throughout the country, it is necessary to research pesticide residues in several similar sites in most districts of the Republic, such as several lands with hetero-oleaginous crops (lavender, sage, mint) from at least 10-15 districts or localities in the Northern, Central and Southern areas of the Republic.

Carrying out such extensive research requires considerable funding. We mention that the services of the accredited Laboratory for testing a sample of biological material (honey, pollen) for the content of pesticide residues cost 1600 lei/sample.

This year, the Beekeeping Group of the Institute of Zoology took a total of 20 samples of biological material and tested them in this Laboratory, which cost a total of 32000 lei. All payments were made from the researchers' own account, because the Institute did not allocate financial means for these services, despite the fact that we proposed the planning of these means for the State Program Project.

According to us, the continuation of research in this direction can only be resumed within a separate research project of the State Program entitled *"Evaluation, mapping and certification of sites with*

compliant honey flora for organic beekeeping and the production of organic bee products". Such a research project could also be co-financed from the ecological fund of the Ministry of Ecology.

CONCLUSIONS

In the pollen and honey samples, taken from the bee families located at the lavender picking, no detectable concentrations of residues of any of the 63 tested pesticides were detected (*Acetamipirid, Chlothianidin, Imidacloprid, Thiacloprid, Tiametoxam, Bifentrin, Ciflutrin, Cipermetrin, Deltametrin, Fenvalerat, Lambda-Ghalotrin, Tau-fluvalinat, Clorpirifos, Endosulfan, HCH izomeri, Diazinon, Diclorvos, Dimetoat, Ethion, Fenitrotion, Fosalon, Malation, Permetrin, Pirimitos-metil, Protenotos, Fenixicarb, Fipronil, Indoxacarb, Pirinicarb, Azoxistrobin, Bitertanol, Bromuconazol, Ciproconazol, Difenoconazol, Diniconazol, Epoxiconazol, Flutriafol, Penconazol, Picoxistrobin, Propiconazol, Tebuconazol, Tiadimeton, Boscalid, Kresoxim-metil, Benzanton, Captan NIM, Ciprodinil, Clorotalonil, Dimetomorf, Folpet NM, Iprodion, Procimidon, Spiroxamină, Vindozolin, Pirimetanil, Haloxifop, Glifosat, Pendimetalin, Prometrin, Trifluralin, Lufenuron, Piridaben, Propargit*).

In the pollen and honey samples, taken from the bee families located at the sage harvest, no detectable concentrations of residues of any of the 63 tested pesticides were detected.

The bee products (pollen and honey), obtained from the bee families located at the lavender and sage harvests in the researched fields, are ecologically clean (bio) in terms of the content of pesticide residues, and the respective lavender and sage sites are compliant for practicing organic beekeeping.

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