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THE CONTENT OF CERTAIN HEAVY METALS IN TISSUES AND PRODUCTS OF HONEY-BEES UNDER THE CONDITION OF THEIR FEEDING WITH NATIVE SOY FLOUR ADDING CHLORIDE AND AQUANANO CHROME CITRATE

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The influence of feeding with native soy flour, adding chloride and aquanano chrome citrate, on the content of chrome, zink, cuprum, ferrum, cadmium, and plumbum in the tissues of a head, thorax, abdomen and the whole body of honey-bees, as well as in the honey, pollen, and honeycombs was studied. The study specified the probable intergroup differences according to the content of chrome, zink, cuprum, ferrum, cadmium, and plumbum (mg/kg body weight) in tissue samples of a head, thorax, abdomen and the whole body. In the tissues of the bee head in the control, second, and third experimental groups — according to zink content — 12.73; 10.13 (p<0.01); 8.60 (p<0.001) and ferrum — 49.01; 45.40 (p<0.05); 38.53 (p<0.001). In the tissues of the bee thorax in the second and third experimental groups the decrease of zink content is indicated — 8.03 (p<0.01); 8.43 (p<0.01); 11.22 when compared with the control group at a time when ferrum content is increased — 61.46 (p<0.01); 61.61 (p<0.01); 50.78. In the tissues of the abdomen in the second and third study groups if compared with the indications of the control group, the increase of ferrum content is determined — 43.61 (p<0.02); 42.50 (p<0.02); 39.03. It is also indicated that there is an increase in the tissues of the whole bee body in the second experimental group when compared with the chrome control level — 2.70 (p<0.05) 1.90 and ferrum in the second and third experimental groups — 49.18 (p<0.001); 44.76 (p<0.001); 34.51. The content of cuprum, cadmium, and plumbum in the tissue samples of both experimental groups didn't significantly differ when compared with the control group. In the pollen samples in the third experimental group the increase of cuprum content is indicated (for 42.9 %, p<0.02) at a time when ferrum content is decreased (for 3.8 %, p<0.05) when compared with the control group indications. The cuprum content in the honeycombs in the third experimental group also increased for 83.2 % (p<0.02) when compared with the control group indications. Whereas the chrome content in the honeycombs in the second experimemtal group increased for 29.9 % (p<0.05) and there is a tendency to its higher level in the honey and pollen samples in both the second and the third groups.

Keywords: BEES, HEAVY METALS, SOY, CHROME CHLORIDE, AQUANANO CHROME CITRATE

ВМІСТ ОКРЕМИХ ВАЖКИХ МЕТАЛІВ У ТКАНИНАХ І ПРОДУКЦІЇ МЕДОНОСНИХ БДЖІЛ ЗА УМОВ ПІДГОДІВЛІ БОРОШНОМ НАТИВНОЇ СОЇ З ДОДАВАННЯМ ХЛОРИДУ ТА АКВАНАНОЦИТРАТУ ХРОМУ

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Досліджено вплив згодовування борошна нативної сої з додаванням до нього хлориду та аквананоцитрату хрому на вміст Хрому, Цинку, Міді, Заліза, Кадмію та Свинцю у тканинах голови, грудей, черевця та цілого організму медоносних бджіл, а також у меді, перзі і стільниках. Дослідженнями встановлені вірогідні міжгрупові різниці за вмістом Хрому, Цинку, Міді, Заліза, Кадмію та Свинцю (мг/кг маси тіла) у зразках тканин голови, грудей, черевця та цілого організму. У тканинах голови бджіл контрольної, II і III дослідних груп — за вмістом Цинку — 12,73; 10,13 (p<0,01); 8,60 (p<0,001) і Заліза — 49,01; 45,40 (p<0,05); 38,53 (p<0,001). У тканинах грудного

відділу тіла бджіл II і III дослідних груп, відзначено зниження вмісту Цинку — 8,03 (p<0,01); 8,43 (p<0,01); 11,22 порівняно до контрольної на тлі зростання вмісту Заліза — 61,46 (p<0,01); 61,61 (p<0,01); 50,78. У тканинах черевця II і III дослідних груп порівняно до показників контрольної групи встановлено зростання вмісту Заліза — 43,61 (p<0,02); 42,50 (p<0,02); 39,03. Встановлено також зростання у тканинах цілого організму бджіл II дослідної групи порівняно до контролю рівня Хрому — 2,70 (p<0,05) 1,90 і Заліза у II та III дослідних групах — 49,18 (p<0,001); 44,76 (p<0,001); 34,51. Уміст Міді, Кадмію та Свинцю у зразках тканин обох дослідних груп порівняно до контрольної групи суттєво не відрізнявся. У зразках перги III дослідної групи відзначено зростання вмісту Купруму (на 42,9 %, p<0,02) на тлі зниження вмісту Феруму (на 3,8 %, p<0,05) порівняно до показників у контрольній групі. Зростав також вміст Купруму у стільниках III дослідної групи на 83,2 % (p<0,02) порівняно до показників вмісту у контрольній групі. Тоді як вміст Хрому зріс у стільниках II дослідної групи на 29,9 % (p<0,05) проявляючи тенденцію до його більш високого рівня у зразках меду і перги бджіл як II, так і III дослідних груп.

Ключові слова: БДЖОЛИ, ВАЖКІ МЕТАЛИ, СОЯ, ХЛОРИД ХРОМУ, АКВАНАНОЦИТРАТ ХРОМУ

СОДЕРЖАНИЕ ОТДЕЛЬНЫХ ТЯЖЕЛЫХ МЕТАЛЛОВ В ТКАНЯХ И ПРОДУКЦИИ МЕДОНОСНЫХ ПЧЕЛ ПРИ ПОДКОРМКЕ МУКОЙ НАТИВНОЙ СОИ С ДОБАВЛЕНИЕМ ХЛОРИДА И АКВАНАНОЦИТРАТУ ХРОМА

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Исследовано влияние скармливания муки нативной сои с добавлением к нему хлорида и аквананоцитрата хрома на содержание Хрома, Цинка, Меди, Железа, Кадмия и Свинца в тканях головы, груди, брюшка и целого организма медоносных пчел, а также в мёде, перге и сотах. Исследованиями установлены достоверные межгрупповые различия по содержанию Хрома, Цинка, Меди, Железа, Кадмия и Свинца (мг/г массы тела) в образцах тканей головы, груди, брюшка и целого организма. В тканях головы пчел контрольной, II и III опытных групп — по содержанию Цинка — 12,73; 10,13 (p<0,01); 8,60 (p<0,001) и Железа — 49,01; 45,40 (p<0,05); 38,53 (p<0,001). В тканях грудного отдела тела пчел II и III опытных групп, отмечено снижение содержания Цинка — 8,03 (p<0,01); 8,43 (p<0,01); 11,22 по сравнению с контрольной на фоне роста содержания Железа — 61,46 (p <0,01); 61,61 (p <0,01); 50,78. В тканях брюшка II и III опытных групп по сравнению с показателями контрольной группы установлено повышение содержания Железа — 43,61 (p<0,02); 42,50 (p<0,02); 39,03. Установлено также рост в тканях всего организма пчел II опытной группы по сравнению с контролем уровня Хрома — 2,70 (p <0,05) 1,90 и Железа во II и III опытных группах — 49,18 (p<0,001); 44,76 (p<0,001); 34,51. Содержание Меди, Кадмия и Свинца в образцах тканей обеих опытных групп по сравнению с контрольной групой существенно не отличались. В образцах перги III опытной группы отмечено повышение содержания Меди (на 42,9%, p<0,02) на фоне снижения содержания Железа (на 3,8 %, p<0,05) по сравнению с показателями в контрольной группе. Возросло также содержание Меди в сотах III опытной группы на 83,2% (p<0,02) по сравнению с показателями содержания в контрольной группе. Тогда как содержание Хрома увеличелось в сотах II опытной группы на 29,9 % (p<0,05) проявляя тенденцию к его более высокому уровню в образцах мёда и перги пчел как II, так и III опытных групп.

Ключевые слова: ПЧЕЛЫ, ТЯЖЕЛЫЕ МЕТАЛЛЫ, СОЯ, ХЛОРИД ХРОМА, АКВАНАНОЦИТРАТ ХРОМА

Under the condition of modern agricultural production conducting and getting safe raw materials and hive products that are free of GMO and chemicals that are uncharacteristic for food products — pollutants, that don't exceed maximum allowable concentration, are of great importance for the preservation of high bioactivity of honey, pollen, royal jelly, and other hive products. The study of the last years claims that honey-bees can selectively deposit in their tissues certain heavy metals — cadmium and plumbum, as well as tetracyclines, sulphamines and other contaminants that get into their organisms in the alimentary way, from nectar and pollen of honey plants [1–5]. At the same time at modern stage of beekeeping development the bee feeding technologies using protein and fatty additives, the components of which influence physiological and biochemical processes in honey-bee orgamisms, are widely introduced [6]. The usage of native soy flour that contains antinutrients — phytoestrogens, protease inhibitors, phytates, saponins, and phytosterins, can specifically influence not only protein and lipid metabolism, but also the metabolism of certain mineral elements in the worker bee organisms. It is known that soy flour is not only essential source of proteins and lipids, but also of micro- and macroelements, and can effectively compete with other ectogenous protein and fatty components, including those of synthetic origin. The usage of basic methods for chemical analysis of natural soy cultivars for the content of micro- and macroelements notably higher content of potassium (by 2–11 times), calcium (by 4–15 times), magnesium (by 2.4–3 times), phosphorus (by 1.4–2.3 times), sulphur (by 1.8–4.3 times), ferrum (by 1.8–8 times), manganese (by 1.5–4 times), cobalt (by 5.6–19 times), and chrome (by 1.3–5.7 times) was indicated when compares with the content of these elements in other leguminous crops, in particular beans, peas, wheat, oats, and rice. However, the soy flour is characterized by relatively lower sodium, cuprum, zink, and strontium content [8]. From the literature data it is known about positive changes in the development of hypopharyngeal, mandibular, and occypital glands under the condition of honey-bee feeding with the flour on the base of soy soybeans. However, the combined effect of the soy components, adding trace elements to the flour is still unclarified [9, 10]. Because of this, introduction of mineral and organic chromium compounds to the soybeans flour as the feed additive for honey-bees was applied for the first time. The influence of chrome (III) in physiological concentrations on the tissues and body fluids is well known, as it stipulates the intensification of metabolism [11]. Whereas under the condition of its excess in an animal body such stimulative metabolic effect is absent. An important characteristic of chrome (III) is good solvability of its salt that results in the maximum fixation of this microelement in the animal or plant organisms. However, the basic mass of chrome (III) stays in the plant roots and only insignificant part of this element is transported to the above-ground organs, including an inflorescence that causes low Cr (III) content in nectar and pollen [6, 12]. As the result, pollen and nectar can provide bee need of chrome to a small extent only. That is why, in modern beekeeping it's rather promising to use Cr (III) in the form of citrates, as it is the most convenient microelement compound to be fixed in the organism. Metal citrate is a good conductor of the elements into a cell, as well as it is an essential intermediary substrate of tricarboxylic acid cycle. The usage of Cr (III) in the form of citrate is 9-10 times more effective when compared with the inorganic compounds, while their fixation in the organism makes up only 0.4 and 2.0 % [11]. Despite this, Cr (III) can also change enzymatic activity by influencing the level and physiological availability of other microelements that are co-factors of these enzymes. It is known that an increased content of mineral elements and colloid substances, in particular dextrins that are in a great amount in the honeydew in summer and autumn periods, that significantly decrease the honey-bee life expectancy during the winter anabiosis, causing preterm defecation — non-infectious diarrhea. Because of this, scientific and practical interest is introduced by the study of influence of different chrome (III) level in the combination with the soy flour on the content of Cr (III) and other such elements as Fe, Zn, Cu, Cd, Pb in the tissues of different anatomic sections of a bee body in the summer and autumn periods of bee life and reproduction.

Materials and Methods

The experiment was conducted in the summer and autumn periods (August-September) for three groups of honey-bees of the Carpathian species, three honey-bee colonies in each group. The bees of control (first group) and experimental (second and third) groups are kept at the stationary conditions, consuming natural feed and accumulated pollen stock. In the bee feeding of the second experimental group native soy flour was used (Chernivetska-9) in the amount of 200 gr/honey-bee family/week, adding to this previously dissolved in 50 ml 60 % sugar syrup $CrCl_3 \times 6H_2O$ in the amount of 7.7 ml that is an equivalent to 1.5mg pure chrome. The bees of the third experimental group in addition to the same amount of soybean flour of native variety (200 g/bee family/week) got 0.2 ml of the aquanano chromium citrate, dissolved in 50 ml of 60 % sugar syrup, which is equivalent to 60 mcg of chromium. The experiment lasted for 35 days with an additional nutrition interval of 7 days. The control and experimental bee groups do not have any infectious and invasive diseases. The studied material samples, namely, 90–100 bees from a group (30–35 bees from a beehive), which were later cut onto such separate anatomical body parts as a head, thorax, abdomen, and the whole organism, as well as honey and pollen with the beeswax foundation, the area of which is 20–25 cm^2, were selected at the final stage of feeding with soy and chromium compounds (35^{th} day). The content of Cr, Cu, Fe, Zn, Cd, and Pb was determined with the help of the SF–115 PC atomic absorption spectrometer in the control and experimental tissue samples of the head, thorax, abdoment and whole organism of the worker bees, as well as in the honey, pollen, and combs.

The obtained numerical values were processed by the standard Microsoft EXCEL statistical software package with the definition of the average values (M) and their deviations (± m) and degree of possible intergroup differences with the help of the Student’s factor (P).

Results and discussion

It is known that honeybees are able to selectively accumulate certain microelements, including heavy metals. This can be determined by their level in the plant nectar and pollen, and it can be also caused by other alimentary factors, including exogenous intake with the bee feeding components and water. However, their intake into the organisms of animals is necessary because most microelements are included in the active sites of enzymes together with cofactors of biochemical catalysis in metabolism reactions of proteins, lipids, and hydrocarbons in organisms of the animals, and Pb and Cd, even in microamounts, are used to determine the possible toxic effect.

It is essential to note that the content of some heavy metals in the tissues of bees varies greatly. The lower concentrations of zinc ($p<0.01$) in the bee head tissues of the second (79.6 %) and third (67.5 %, $p<0.001$) experimantal groups when compared to the control group (Table 1) were found out. The significant changes according to the ferrum content were observed in the bee head tissues of both experimental groups regarding its level in the control group bees. In particular, the substantial reduction of iron in the bee head tissues of the second (7.4 %, $p<0.05$) and third (21.4 %, $p<0.001$) experimental groups when compared with its content in the head tissue samples of the control group bees was determined. The decrease of zinc and ferrum content in the bee head tissues of both experimental groups can be directly linked to the inhibitory influence of the antinutrient substances that are part of the chemical composition of natural soy beans. These demineralizing factors or substances, which are capable of making inhibitory effect on the fixation of certain mineral food elements (mostly Ca, Fe, Zn), include phytic acid that is found in large quantities in the natural soy beans. The mechanism of inhibitory action of phytic acid is connected with its strong chelating properties that contribute to the formation of strong insoluble (chelate) complexes with the mineral elements, necessary for animal nutrition. These are the following: Ca, Mg, Fe, Zn, Cu and aminoacids. It is known that the metal chelates are insoluble even at pH 3–4 and they are poorly absorbed in the digestive tract.The study found out that the inclusion of soy proteins in the feed ration of the animals reduces the availability and fixebility of such metals as: Zn, Mg, Fe [13].

Table 1

The content of some heavy metals in tissues of honeybees mg / kg natural weight (M ± m, n= 3)

Heavy metals	Groups of honey bees		
	I — control, natural food	II — research, soybeans native + Chromium chloride	III — research, soybeans native + akvananotsytrat chromium
Department head			
Cr	1.84±0.20	1.57±0.18	1.64±0.15
Zn	12.73±0.40	10.13±0.39**	8.60±0.16***
Cu	2.05±0.28	1.66±0.15	1.35±0.10
Fe	49.01±0.94	45.40±0.63*	38.53±0.68***
Cd	Traces	Traces	Traces
Pb	2.51±0.22	2.35±0.21	2.65±0.20
Department thoracic			
Cr	1.88±0.20	1.95±0.28	1.98±0.24
Zn	11.22±0,39	8.03±0.45**	8.43±0.29**
Cu	2.25±0.19	2.57±0.21	2.42±0.20
Fe	50.78±0.96	61.46±0.86**	61.61±0.91**
Cd	Traces	Traces	Traces
Pb	2.54±0.12	2.49±0.15	2.63±0.15
Department abdominal			
Cr	2.34±0.27	3.31±0.24	2.83±0.37
Zn	9.70±0.16	10.88±0.44	9.52±0.25
Cu	2.54±0.39	3.32±0.17	3.01±0.11
Fe	39.03±0.77	43.61±0.75*	42.50±0.40*
Cd	Traces	Traces	Traces
Pb	2.57±0.23	2.82±0.21	2.36±0.12
Whole body			
Cr	1.90±0.23	2.70±0.16*	2.32±0.19
Zn	12.23±0.28	11.14±0.70	11.19±0.54
Cu	2.44±0.27	2.79±0.27	2.85±0.11
Fe	34.51±0.73	49.18±0.75***	44.76±0.37***
Cd	Traces	Traces	Traces
Pb	2.50±0.22	2.52±0.20	2.48±0.26

Note: significant difference content of some heavy metals tissues in general, thoracic, abdominal and body of a honey bee II and III experimental groups compared to I control group; * — $P<0.05–0.02$, ** — $P<0.01$, *** — $P<0.001$

Cu is an equally important element necessary for normal physiological and biochemical processes in the honeybee organism. Based on the study results, the Cu content in the head tissues of the second and third experimental groups was 19.0 % and 34.1 % lower in accordance with the data in the control group but the intergroup differences were not likely. The determined variations may indicate intergroup differences of the Cu intake from the food chain and its accumulation in certain body tissues under the influence of chromium chloride and citrate as Cu is involved in metabolic processes. In particular, cuprum is involved in the biochemical processes as part of the electron-carrying proteins that carry out reactions of oxidation of organic substrates by molecular oxygen. It is known that cuprum-containing amine oxidases, which are widely spread in natural conditions, participate in the reactions of catabolism and inactivation of a number of physiologically active amines in the organisms of animals. In particular, they take part in the inactivation of histamine, which contains a large number of bee venom and is an active physiological metabolite that increases the permeability of the vessel walls and makes changes to the system of microcirculation and sensibility of the dermatic capillaries. Together with MSD (peptide — 401) and hyaluronidase enzyme it leads to a general local hypersensitivity reaction, caused by the antigen and antibody interaction in the organisms of mammals, to the intake of the toxic peptides, in particular mellitin, the content of which is about 55 % [14]. The peculiaritites of the cuprum metabolism in the body of the honeybees are not sufficiently studied and are the subject for further applied research in this direction.

The analysis of the obtained study results indicates a possible decline of zinc content in the tissues of the bee thorax of the second and third experimental groups at a time when there is an increase of ferrum content in this part in both experimental groups ehrn compared with its indices in the control group.

In particular, the possible (28.3 %, $p<0.01$) reduction of zinc in the second and third (24.9 %) experimental groups was observed when compared with its level in the control tissue samples. It is known that the absorption of zinc from the intestine into the blood of mammals is considerably affected by the high content of nutritional phytate and other such elements as Cd, Cu, and Ca, with which zinc reacts. It is also proven that the increase of protein content in the food ration improves the absorption of zinc, apparently due to the complex of the formed amino acids. Thus, zinc fixation significantly reduces under the conditions of low protein content in the food ration of the animals. The soybeans of natural and GM varieties are characterized by high protein content (36.5–40.3 g%), but the antinutrient substances, present in their content, such as phytates that are found in high concentrations, can exert inhibitory effects on fixation of zinc and reduce its content in the tissues of worker bees. The content of ferrum significantly increased in the thorax tissues of the bees of the second and third experimental groups compared with the control group indices. The values of the possible increase in ferrum level in the thorax of the bees of the second and third experimental groups were equal to 21.0 % and 21.3 % when compared with its content in the control group. Accumulation of ferrum during the ontogenesis process of honey bees is uneven and its largest amount is deposited on the seventh-nineth day of the larval stage. However, it was noted that the highest concentration of ferrum is in the thorax tissues of theadult insect body (emergence phase — 21st day of life) of a working bee [15]. During the normal course of physiological processes, including mineral metabolism in the organism of the worker bees, the concentration of ferrum is on the average 80.36–174.33 mcg/g of dry substance. The maximum content of ferrum is observed in the thorax muscular tissue of bees from 162.61 to 368.87 mcg/g of dry substance. Based on these data it is also important to note that the ferrum content is the highest among all studied microelements in the tissues of all anatomic bee body parts; this value ranges from 37.5 to 68.2 mg/kg [16]. Similar changes and possible differences were observed in the increase of the ferrum content in the abdomen tissues of the bees of the second (11.7 %, $p<0.02$) and third (8.9 %) experimental groups when compared with its content in the abdomen tissue samples of the worker bees in the control group. The ferrum concentration increases significantly at all stages of holometamorphosis under the conditions of its nutritional intake into the organism of the honey bees. Its concentration at the adult insect stage changes because the ferrum level increases in most thorax tissues, which can significantly affect its content in hive products.

It is proven that the main part of ferrum, as well as of some other macro- and microelements, is concentrated in chitine, which belongs to polysaccharides and consists of 18 acetylated glucosamine residues [9]. It is obvious that the deposition peculiarity of the abdomen tissues of the worker bees concerning Fe may be caused by their orientation in space. Chitine covers the entire exoskeleton surface of the working bees providing strength and resistance of the tissues, as well as the significant biological ferromagnetism, due to to the metals — ferromagnets — that are contained in its exocovers. Besides, it is known that honey bees are oriented in space due to the magnetic field of the Earth. This is connected with the content of the magnetite crystals in the tissues of the abdomen biological ferromagnet. They have sizes of 300–350 Å and are comprised of Fe, Co, Mg and Cr. This group of metals (biological ferromagnets) provides for conservation of the magnetic field after the magnetic force influence termination [12]. Such morphological and physiological characteristics of the honey bees have ethological and economical value. It is known that old worker bees (18–25 days old) are oriented in space by the Earth's magnetic field, and young bees (12–15 days old) build nest combs in the direction of the magnetic field [9].

The analysis of the obtained data indicates considerable changes in the chromium content with its possible increase in the bee tissues of the second (42.1 %, $p<0.05$) experimental group, and also probable ($p<0.001$) increase in the content of ferrum in the bee tissues of the second (42.5 %) and third (29.7 %) experimental groups when compared with its level in the control group. The determined differences of individual microelements content in the tissues of the bees can be caused by unequal levels of these elements in plant pollen and biotransformation in the organisms of bees.

The study of the plant pollen sample based on the degree of maximum deviation and proportion in the content of mineral elements indicates their significant differences [4, 17]. It is proven that the content of P, Ca, and Mg in the pollen of various plants can range up to 20 %, and these elements content in all other minerals can be in the range from 1 to 15 %. The plant pollen and nectar also contain such ultramicroelements (concentration — 0.000001 %): Ag, W, Mo, Pd, Si, Pt, Sr, and others. When these trace elements are absent, there may emerge metabolic disorders because they are able to provide a stimulating effect on the physiological processes, showing both the synergistic and the antagonistic effect onto the other mineral elements. Their direct and indirect effects on the metabolism in the tissues and fluids of animal organisms were also observed.

According to the results of the content study of some heavy metals in honey, pollen, and combs of the bees of the second and third experimental groups, some differences in their values were found out when compared with the samples in the control group. In particular, the pollen of the third experimental group was characterized by an increase in the content of cuprum (42.9 %, $p<0.02$) at a time when there was a reduction of ferrum (3.8 %, $p<0.05$) when compared with its indices in the control group (Table 2). The content of cuprum also increased in the combs of the third experimental group by 83.2 % ($p<0.02$) when compared with its content indices in these samples in the control group. While the chromium level ($p<0.05$) increased possibly by 29.9 % only in the combs of the second experimental group when compared with the control group, showing only its tendency to higher levels in the honey and pollen samples of the bees of both the second and the third experimental groups.

Thus, study results showed that the alimentary factors significantly affect the intake of heavy metals into the organisms of bees and their content in some of their anatomical parts and the whole body, as well as the level in such products as honey, combs, and pollen. Such changes in the content of some heavy metals both in the tissues of the worker bees and in the products can be directly related to the bee forage.

Table 2

The content of some heavy metals in honey, comb and perge, mg/kg of natural mass (M ± m, n = 3)

Heavy metals	Group of honey bees		
	I — control, natural food	II — research, soybeans native + Chromium chloride	III — research, soybeans native + akvananotsytrat chromium
Honey			
Cr	0.77±0.12	0.92±0.19	0.83±0.22
Zn	2.38±0,10	2.33±0.11	2.70±0.10
Cu	0.73±0.12	0.70±0.16	0.69±0.11
Fe	11.68±0.16	12.15±0.16	11.90±0.15
Cd	Traces	Traces	Traces
Pb	0.25±0.02	0.22±0.06	0.20±0.02
Beebread			
Cr	2.39±0.20	3.12±0.18	2.67±0.22
Zn	4.65±0.17	4.07±0.25	4.81±0.10
Cu	2.75±0.24	2.52±0.22	3.93±0.10*
Fe	75.58±0.56	73.72±0.64	72.74±0.54*
Cd	Traces	Traces	Traces
Pb	2.48±0.20	2.55±0.13	2.43±0.11
Honeycomb			
Cr	2.14±0.11	2.78±0.16*	2.33±0.12
Zn	3.75±0.14	3.59±0.15	3.64±0.10
Cu	1.43±0.23	2.07±0.13	2.62±0.21*
Fe	49.35±0.66	48.19±0.60	47.63±0.54
Cd	Traces	Traces	Traces
Pb	0.47±0.03	0.45±0.03	0.46±0.03

Note: significant difference to individual heavy metals in honey, perge and cell II and III experimental groups compared to I control group; * — P<0.05–0.02

In particular, when there is an intake of the honey plant nectar and pollen into the nest because it is known that the content of mineral elements in nectar and pollen varies significantly depending on the botanical origin and growing period of these plants. Some corrective effect is also caused by the components of artificial protein and mineral bee feeding.

Conclusions

1. Adding native soybean flour and chromium chloride to the sugar syrup of the summer and autumn bees feeding in the second experimental group andaquanano chromium citrate in the third experimental group resulted in significant (by 20.4 % and 32.5 %) decrease in zinc and ferrum content in the tissue samples of the bee head and also in the pollen of the second experimental group when compared with the control group.

2. The influence of natural soybean components is controversial on the concentration of heavy metals in the organisms of bees, causing probable growth (21.0 % and 21.3 %, 11.7 % and 8.8 %, and 42.5 % and 29.7 %) of the content of ferrum in the tissues of the thorax, abdomen, and whole bee organism of the second and third experimental groups at a time when there is a possible decrease (28.3 % and 24.9 %) of zinc in the tissues of the thorax when compared with their content in the tissues of the control group bees.

3. Feeding bees with soy flour with chromium chloride additive (1,5 mg/ml of 50 ml/60 % of sugar syrup) caused a probable growth (42.1 % and 29.9 %) of Cr content in the tissues of the whole organism and combs of the bees of the second experimental group

with the preservation of its tendency to higher levels in the tissues of the thorax and abdomen of the bees of the same group, while applying aquanano chromium citrate (60 mg/50 mg/60 % of sugar syrup) in the third experimental group resulted in increase of Cu level in the pollen and combs and tendency to a higher content of Cr in tissues of thorax, abdomen, and whole organism of the bees, as well as in honey, combs and pollen.

Prospects for Further Studies. In the future, based on the obtained study results, it is advisable to determine the effect of other mineral and organic compounds of the essential microelements and their complex combination with natural soy flour onto the content of some heavy metals in the body tissues of honey bees and their products.

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