UDC 613.22:547.841.547.562 DOI: 10.33273/2663-9726-2020-52-1-32-39

RELEVANCE OF THE PROBLEM OF DIOXINS AND POLYCHLORINATED BIPHENYLS (PCBs) DETERMINATION IN BABY FOOD PRODUCTS

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ABSTRACT. The Aim of the Article. *Analysis of the current state of the problem of the dioxins and polychlorinated biphenyls (PCBs) determination in baby food products and the development of sample preparation methods for determining these xenobiotics in food products for infants and young children.*
Dioxins form a group of structurally and chemically related chlorinated tricyclic oxygen-containing aromatic compounds (congeners), which includes 75 polychlorinated dibenzo-para-dioxins (PCDDs) and 135 polychlorinated dibenzofurans (PCDFs). The most toxic congeners of dioxins, in which chlorine atoms along with other positions are necessarily in 2,3,7,8 positions of benzene rings. Their total number is 17:7 PCDD congeners and 10 PCDF congeners. A group of polychlorinated biphenyls (PCBs) – chlorinated bicyclic aromatic compounds, which consists of 209 different congeners, 12 of which have a spatial and electronic structure and exhibit toxicological properties similar to dioxins, therefore, they are called dioxin-like PCBs (DL-PCBs). In addition, when monitoring food products as a marker, a group of 6 PCBs was selected that did not exhibit dioxin-like toxicity and therefore did not belong to dioxin-like PCBs (NDL-PCBs). Thus, of the total number of 419 PCDDs, PCDFs and PCBs, only 35 are toxicologically significant, therefore, these compounds are subject to control in baby food products. To control the content of the amount of dioxins, the amount of dioxins and DL-PCBs and the amount of NDL-PCBs in foods for infants and children from one to three years in Ukraine, the maximum levels of these compounds on the basis of the order of the Ministry of Health of Ukraine No. 368 of 05/13/2013 were harmonized with the maximum allowable levels in foods for infants and young children in accordance with Commission Regulation (EU) No. 1259/2011.
Methods for the analysis of dioxins and PCBs. *Two instrumental analysis methods are used to determine dioxins and dioxin-like PCBs in foods for baby food: 1) a combination of high-resolution (capillary) gas chromatography with high-resolution mass spectrometry (GC/MS); 2) a combination of GCHR with tandem mass spectroscopy (GC/MS/MS). High-resolution (capillary) gas chromatography is used to determine non-dioxin-like (marker) PCBs. The stage of sample preparation, including the stages of extraction and purification, is key in determining dioxins and PCBs.*
Conclusions. *The stage of sample preparation using automatic devices (liquid extraction under pressure, an automated extract purification system) and chromatographic columns was developed to further determine the mass concentration of dioxins and PCBs in baby food products. The developed procedures using devices for the automatic extraction and purification of the obtained extracts from baby food samples will make it possible in the future to determine PCDDs/PCDFs, ortho-unsubstituted, mono-ortho-substituted and marker PCBs in one sample.*
Key Words: *dioxins, polychlorinated biphenyls, baby food.*

Introduction. At present, it is generally recognized that food is the main source of exposure to the human body of persistent organic pollutants (POPs), which include a group of structurally and chemically related chlorinated tricyclic oxygen-containing aromatic compounds (congeners), which are combined by the general term – dioxins [1-3]. Dioxins include 75 polychlorinated dibenzo-para-dioxins (PCDDs) and 135 polychlorinated dibenzofurans (PCDFs). The most toxic congeners of dioxins, in which chlorine atoms along with other positions are necessarily in 2,3,7,8 positions of benzene rings. Their total number is 17:7 PCDD congeners and 10 PCDF congeners. The most toxic congener of dioxins is 2,3,7,8-tetrachlorodibenzo-para-dioxin (2,3,7,8-TCDD). A group of polychlorinated biphenyls (PCBs) – chlorinated bicyclic aromatic compounds, which consists of 209 different congeners, 12 of which have a spatial and electronic structure and exhibit toxicological properties similar to dioxins, is adjacent to dioxins, therefore they are called dioxin-like PCBs (DL-PCB). The remaining PCBs that do not exhibit dioxin-like toxicity, and therefore are non-dioxin-like PCBs (NDL-PCBs). The DL-PCB group consists

of 4 non-ortho-substituted congeners (PCB 77, PCB 81, PCB 126, PCB 169) and 8 mono-ortho-substituted congeners (PCB 105, PCB 114, PCB 118, PCB 123, PCB 156, PCB 157, PCB 167, PCB 189). The most toxic congener of DL-PCB is PCB 126. The group of scientific experts on food chain contamination of the European Food Safety Authority (EFSA) decided to use the sum of six indicator NDL-PCBs (PCB 128, PCB 52, PCB 101, PCB 138, PCB 153, PCB 180) when monitoring food and fodder, as these congeners proved to be suitable indicators for different PCB samples in different matrices and are most suitable for assessing the risk of NDL-PCB based on available data [4]. Thus, of the total number of 419 PCDDs, PCDFs and PCBs, only 35 are toxicologically significant and they are subject to control in agricultural and food raw materials, food products and animal feed.

According to the WHO, the best feeding of the child is breastfeeding during the first 6 months of life, followed by the introduction of complementary foods corresponding to the age and continued breastfeeding for up to 2 years or more [5]. At the same time, in some EU countries only about 50 % of mothers initiate breastfeeding [2]. According to statistics, few European women breastfeed their children up to six months [6] and only 33.1% of infants in the United States breastfeed exclusively with breast milk under the age of 3 months. In Ukraine, not all children are only breastfed, too.

In connection with this state of affairs, the industry produces baby food products that play an important role in the diet of infants and young children. Therefore, it becomes very important to control the content of persistent organic pollutants in these products, and in particular, dioxins and PCBs, as well as the development of methods for their identification and quantification.

Legislation and Regulation of Dioxins and Polychlorinated Biphenyls in Baby Foods in the EU

The EU general procedures for contaminants in food products are established by EU Regulation of February 8, 1993 No. 315/93 [7]. According to this document, any substance that is inadvertently added to a food product that is present in it as a result of production can become a pollutant. This process consists of many components: growing crops, livestock and veterinary control, refining, preparation, processing, packaging, pre-packing, transportation, as well as storage and the environment. A food product contaminated in an amount unacceptable from the point of view of public health and, in particular, contained at a toxicologically significant level, should not enter the market. To protect human health, the maximum allowable amounts (limits) are established for specific pollutants in consumed food products. They must be adopted by the EU and may include: 1) limits for the same contaminant in different foods; 2) the analytical limits of detection and quantification; 3) links to food sampling methods and analysis methods that will be used to control pollutants.

In the EU, the maximum allowable levels of contaminants in food are developed by the European Commission, which are then accepted or rejected by the European Parliament and the European Council. An important role in establishing the actual levels of contaminants in food consumed by the EU population and in assessing their health hazards is played by the European Food Safety Authority (EFSA) [8] represented by the Food Chain Contaminants Group (EFSA Panel) on Contaminants in the Food Chain (CONTAM) [9].

The European Commission's Scientific Committee on Nutrition has established for humans the allowable weekly intake (TWI) of dioxins and dioxin-like PCBs with food at a level of 14 pg WHO-TEQ/kg [10]. This value corresponds to a temporary allowable monthly intake (TMI) of human dioxins of 70 pg WHO-TEQ/kg, established by the Joint FAO/WHO Expert Committee on Food Additives in 2001 [11], and falls at the lower end of the TDI range of 1-4 pg/kg for dioxins and dioxin-like PCBs, established by the WHO Meeting in 1998 [10].

In accordance with these values, the EU Commission Regulation in 2006 established the maximum levels (MLs) for dioxins and the sum of dioxins and dioxin-like PCBs in food products [12]. It was noted that special attention should be paid to the establishment of especially low levels of dioxins and dioxin-like PCBs in foods for newborns and young children, taking into account the data obtained as a result of monitoring programs of dioxins and dioxin-like PCBs in foods for newborns and young children for 2005 – 2007.

In setting maximum levels in foods for children, the European Commission Scientific Committee on Nutrition took into account that children,

especially infants, may be more biologically sensitive to certain toxicants than adults, based on body weight. Current data on the metabolic rate and case studies indicate that infants under 6 months of age usually lack physiological capabilities to detoxify and remove toxic substances from the body, comparing to adults [13]. The table shows the maximum allowable levels of dioxins (WHO-PCDD/F-TEQ), sums of dioxins and dioxin-like PCBs (WHO-PCDD/F-PCB-TEQ), and amounts of non-dioxin-like (indicator) PCBs (ICES-6) in food for infants and young children established by Commission Regulation (EU) No. 1259/2011 [14].

The established maximum allowable levels are the basis for preventing highly contaminated baby food products from entering the EU market and a necessary tool for managing the risk associated with dioxins and PCBs and the unified application of these standards throughout the EU.

In the EU, constant monitoring of dioxins and PCBs presence in food products, including baby food, is considered mandatory and necessary [15]. In the EU, there are three levels of state laboratories that monitor dioxins and PCBs in food: 1) official laboratories (OFLs), which are appointed by the competent authorities of the Member States to analyze samples taken during official control; 2) national reference laboratories (NRLs); and 3) EU reference laboratories (EURLs). The network of NRL and EURL detection systems for the analysis of dioxins and PCBs includes laboratories from 27 EU member states [3].

A laboratory performing analyzes for the content of dioxins and PCBs must be accredited for this type of activity by a recognized body in accordance with the requirements of the International Standard ISO/IEC 17025: 2017 «General Requirements for the Competence of Testing and Calibration Laboratories». Laboratory management is obliged to guarantee the competence of all those working with special equipment, conduct analyzes, evaluate the results and sign protocols containing the results of the performed analyzes.

Legislation of Ukraine on the Safety and Quality of Baby Food

One of the most important tasks of the state policy of Ukraine regarding baby food is to provide infants and young children with baby food of proper quality and safety in order to reliably protect the baby body from the dangers that may accompany such products. In Ukraine, the basic requirements for the production of baby food are formulated in the laws of Ukraine «On Baby Food» [16], «On the Protection of Childbirth» [17], «On the Preschool Education» [18], «On the Basic Principle of Requirements to Safety and the Taste of Food Products» [19], «On Milk and Dairy Products» [20], «On the Introduction of Amendments to the Relevant Legislative Acts of Ukraine» [21], and in other regulatory documents [22, 23, 24].

An important role in the production of domestic baby food of proper safety and quality is played by regulatory documents [25, 26], which contribute to the introduction of domestic food safety and quality control system HACCP (Hazard Analysis and Critical Control Point) [27]. This system allows you to confidently control the production of food products and prevent the manufacture of products that can harm the consumer. State supervision and control over the safety and quality of baby food in accordance with the law of Ukraine «On Baby Food» is carried out by monitoring compliance with the established mandatory safety parameters and the minimum quality specifications of baby food, raw materials, auxiliary equipment and materials for its production.

To control the content of the number of dioxins, the amount of dioxins and DL-PCBs and the

Table

The maximum allowable levels of the amount of PCDDs and PCDFs, the amount of PCDDs, PCDFs and DL-PCBs and NDL-PCBs in foods for infants and young children, expressed in toxic equivalent

Food product	Maximum levels		
	Number of dioxins (WHO-PCDD/F-TEQ)	Number of dioxins and DL-PCBs (WHO-PCDD/F-PCB-TEQ)	Sum of PCB 28, PCB 52, PCB 101, PCB 138, PCB 153 and PCB 180 (ICES-6)
Food products for infants and young children	0.1 pg/g wet weight	0.2 pg/g wet weight	0.1 ng/g wet weight

amount of NDL-PCBs in foods for infants and children from one to three years in Ukraine, the maximum levels of these compounds are based on the order of the Ministry of Health of Ukraine No. 368 of 05/13/2013 [23] are harmonized with the maximum allowable levels in foods for infants and young children in accordance with Com-mission Regulation (EU) No. 1259/2011 [14].

Methods for the Analysis of Dioxins and Polychlorinated Biphenyls (PCBs) in Food Products

Commission Regulation (EU) 2017/644 sets out requirements for sampling methods and analysis methods to control the levels of dioxins, dioxin-like PCBs and non-dioxin-like PCBs in food products [28].

The strong lipophilicity of dioxins and PCBs in combination with the relatively low amounts (ppt (parts per trillion) or less) present as contaminants in the analyzed food matrices makes their analysis very difficult. Quantitative chemical analysis of dioxins and dioxin-like PCBs is possible only using modern physicochemical methods of analysis based on a combination of high-resolution capillary/gas chromatography (HRCGC) with mass spectrometry [3]. The analysis of dioxins and PCBs is a rather expensive procedure compared to the determination of other chemical pollutants, which is naturally a limiting factor for monitoring programs.

The analysis of dioxins and PCBs consists of the following main stages: extraction, purification of the obtained extract using adsorption column chromatography and identification and quantification of analytes using a combination of high-resolution gas chromatography (HRGC) and mass spectrometry.

The stage of sample preparation, including the stages of extraction and purification, is the key in determining dioxins and dioxin-like PCBs. Regardless of the determination method, sample preparation necessarily contains three stages: extraction, purification of the obtained extract and concentration of the purified extracts.

Extraction. Due to the high hydrophobicity of dioxins and PCBs, these compounds, as a rule, are accumulated and located mainly in the lipophilic parts of the analyzed matrices. In this regard, the purpose of the extraction stage is to isolate a lipid fraction containing target analytes from the analyzed matrix. For this, any organic solvents (or mixtures thereof) that are not miscible with water (n-Hexane, a mixture of 10% dichloromethane in n-Hexane, etc.) can be used. To extract dioxins and PCBs from solid matrices, the Pressured Liquid Extraction System (PLE) is currently mainly used. A few grams of lipids isolated from the analyzed matrix is usually necessary for the quantification of dioxins and PCBs.

Purification of extracts. After gravimetric determination of lipid content, fats must be removed in order to enable further analysis. For this purpose, at present, mainly multistage cleaning is used on glass columns filled with silica gel (including modified sulfuric acid) or on ready-made disposable Teflon columns filled with a mixture of acidic, basic and neutral silica gel, basic aluminum oxide and carbon AX-21.

Methods for the identification and quantification of dioxins and PCBs. Two instrumental methods of analysis are used to determine dioxins and dioxin-like PCBs in baby food products - 1) a combination of high-resolution (capillary) gas chromatography with high-resolution mass spectroscopy (HRGC/HRMS) and 2) a combination of HRGC with tandem mass spectroscopy (HRGC/MS/MS). For the determination of non-dioxin-like (marker) PCBs, HRGC is used.

Development of Sample Preparation Procedures for Determining the Content of Dioxins and PCBs in Baby Food

When developing sample preparation procedures (extraction and purification of the obtained extract) in milk-based baby food products, the «Malyshka» dry milk-based mixture with oat flour (a complementary food product for children from 4 months old) enriched with dioxins, dioxin-like and non-dioxin-like PCBs at the maximum level was used.

Extraction procedure. In our studies, when developing a method for the extraction of dioxins and PCBs from dry mixtures of baby food products, we used the Pressured Liquid Extraction System (PLE), Fluid Management System (FMS), Inc., USA.

A weighed portion of dry product (10 g) with 100 g of anhydrous sodium sulfate was carefully ground and mixed in a porcelain mortar, solutions of working internal standards PCDDs/PCDFs and PCBs in n-Hexane (EDF-8999, EC-5385) were added to a weighed portion of the dry mixture in concentration 0.2 ng/ml and the resulting mixture was filled in an extractor column. The extractor column was placed in the PLE system, a pres-

sure of 1500 psi was set, and dioxins, dioxin-like and marker PCBs were extracted in accordance with the PLE 1 3 extraction program with 10% DXM in n-Hexane at a solvent mixture speed of 34 ml/min. The temperature at individual stages of extraction was 108-120 єC. The extract was collected in a 250-ml flat-bottomed flask, then the extract was concentrated on a rotary evaporator in a pear-shaped flask at a water bath temperature of t = 38 ˚ C to ~ 10 ml and the purification of the obtained extract was started.

Cleaning procedure. To clean the extract, a glass column was used (length 300 mm, outer diameter 30 mm), filled from top to bottom with sorbent layers in the following sequence: 3 g of silica gel (Silica gel (Merck) 60 for column chromatography, 0.040-0.063 mm), 6 g of silica gel, impregnated with a 1 M sodium hydroxide solution, 3 g of silica gel, 12 g of silica gel impregnated with concentrated (98%) sulfuric acid, 6 g of silica gel. The column is washed with 50 ml of n-Hexane, the extract obtained is quantitatively applied to the top of the column, and analytes begin to elute with 150 ml of n-Hexane in a 250-ml round-bottom glass flask. After evaporation of n-Hexane on a rotary evaporator to a volume of 0.3-0.5 ml, the residue is transferred to a microvial, the solvent is replaced by n-Nonane, concentrated with nitrogen gas to a final volume of 10 µl of n-Nonane, and analytes are determined.

Conditions for the determination of PCDDs/PCDFs using the combination of HRGC/HRMS

Gas chromatograph Trace GC.

Capillary column: 60 m x 0.25 mm RTX-5 Sil-MS, film thickness 0.25 µm.

The carrier gas is helium, 250 kPa.

Input – 2 µl without dividing the flow.

Injector temperature: 270 ˚C.

Interface temperature: 290 ˚C.

Initial temperature: 120 ˚C.

Starting time: 1 min.

Programming the column thermostat temperature: 120 ˚C - 220 ˚C, 9 ˚C/min, 220 ˚C for 15 min, 220 ˚C - 230 ˚C, 2 ˚C/min, 230 ˚C for 4 min, 230 ˚C - 300 ˚C, 3 ˚C/min, 300 ˚C for 7 minutes.

Mass spectrometer – MAT 95-XP (Thermo Finnigan) with Xcalibur 1.3 data processing system.

The temperature of the ion source: 250 ˚ C.

Ionization – ion impact, 70 eV, detection of positive ions.

Conditions for the determination of DL-PCBs using the combination HRGC/HRMS

Gas chromatograph Trace GC.

Mass spectrometer – MAT 95-XP (Thermo Finnigan) with Xcalibur 1.3 data processing system.

Conditions for the determination of NDL-PCBs using HRGC

Trace GC Ultra Gas Chromatograph with Electronic Capture Detector (ECD).

Capillary column: 60 m x 0.53 mm DB-5, film thickness 0.5 µm.

Programming the column thermostat temperature: initial temperature of 60 ˚C for 1 minute, temperature rise at a speed of 100 ˚C/min to 210 ˚C, temperature rise at a speed of 50 ˚C/min to 2700 ˚C, holding time of the final temperature of 15.5 minutes.

The temperature of the injector is 270 ˚C.

The temperature of the detector is 300 ˚C.

Injection – 2 µl without dividing the flow.

The carrier gas is nitrogen; the gas flow through the column is 4 ml/min.

Quantification Limits (LOQ) of analytes. The limits of quantitative determination of each analyte were determined as a result of processing samples of the «Malyshka» dry mix with standard solutions of the analytes studied. The limits for quantitative determination of PCDDs/PCDFs and DL-PCBs were in the range of 0.01-0.05 pg/g wet weight, and for NDL-PCBs were in the range 0.1-0.3 ng/g wet weight.

Return parameters (Recovery test). The return parameters were determined by adding the analytes under study to the «Malyshka» dry mixture samples, followed by the analysis of these samples as described above. The percentage of return of the studied analytes was in the range of 70-110%.

Conclusions. The stage of sample preparation using automatic devices (liquid extraction under pressure, an automated extract purification system) and chromatographic columns was developed to further determine the mass concentration of dioxins and PCBs in baby food products.

The developed procedures using devices for the automatic extraction and purification of the obtained extracts from baby food samples will make it possible in the future to determine PCDDs/PCDFs, ortho-unsubstituted, mono-ortho-substituted and marker PCBs in one sample.

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АКТУАЛЬНІСТЬ ПРОБЛЕМИ ВИЗНАЧЕННЯ ДІОКСИНІВ І ПОЛІХЛОРОВАНИХ БІФЕНІЛІВ (ПХБ) У ПРОДУКТАХ ДЛЯ ДИТЯЧОГО ХАРЧУВАННЯ

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РЕЗЮМЕ. Мета. *Аналіз сучасного стану проблеми визначення діоксинів і поліхлорованих біфенілів (ПХБ) у продуктах для дитячого харчування та розробка засобів підготовки проб для визначення цих ксенобіотиків у продуктах харчування для дітей грудного та раннього віку.*
Діоксини утворюють групу структурно і хімічно споріднених хлорованих трициклічних кисневмісних ароматичних з'єднань (конгенерів), в яку входять 75 поліхлорованих дибензо-пара-діоксинів (ПХДД) і 135 поліхлорованих дибензофуранів (ПХДФ). Найбільш токсичні конгенери діоксинів, у яких атоми хлору поряд з іншими положеннями обов'язково знаходяться в 2,3,7,8-положеннях бензольних кілець. Загальна їх кількість 17: 7 конгенерів ПХДД і 10 конгенерів ПХДФ. До діоксинів подібна група поліхлорованих біфенілів (ПХБ) – хлорованих біциклічних ароматичних сполук, що становить з 209 різних конгенерів, 12 з яких мають просторову та електронну структуру і виявляють токсикологічні властивості, подібні до діоксинів, які мають назву діоксиноподібних ПХБ (ДП-ПХБ). Крім того, проводячи моніторинг харчових продуктів в якості маркерних, обрано групу з 6-ти ПХБ, які не виявляють діоксиноподібну токсичність, і тому не відносяться до діоксиноподібних ПХБ (НДП-ПХБ). Таким чином, із загальної кількості 419 ПХДД, ПХДФ і ПХБ лише 35 є токсикологічно значущими. Саме тому вони підлягають контролю в продуктах для дитячого харчування. Для контролю за вмістом суми діоксинів, суми діоксинів і ДП-ПХБ і суми НДП-ПХБ у харчових продуктах для немовлят і дітей від одного до трьох років в Україні встановлені максимальні рівні цих сполук на підставі наказу МОЗ України №368 від 13.05.2013 р., які гармонізовані з максимально допустимими рівнями в харчових продуктах для дітей грудного та раннього віку відповідно до Постанови Комісії (ЄС) № 1259/2011.
Методи аналізу діоксинів і ПХБ. Два інструментальних методи аналізу використовуються для визначення діоксинів і діоксиноподібних ПХБ в харчових продуктах для дитячого харчування: 1) поєднання (капілярної) газової хроматографії високої роздільної здатності (ГХВРЗ) з мас-спектроскопією з високою роздільною здатністю (ГХ/МС) і 2) поєднання ГХ з тандемною мас-спектроскопією (ГХ/МС/МС). Для визначення не діоксиноподібних (маркерних) ПХБ використовується ГХ. Етап пробоподготовки, що включає стадії екстракції й очищення, є ключовим при визначенні діоксинів і ПХБ.
Висновки. *Розроблено способи підготовки проб з використанням автоматичної системи для рідинної екстракції під тиском і очищення отриманих екстрактів за допомогою адсорбційної хроматографії, які дозволяють в одній пробі продуктів дитячого харчування проводити визначення масової концентрації діоксинів, діоксиноподібних і маркерних ПХБ.*
Ключові слова: *діоксини, поліхлоровані біфеніли, дитяче харчування.*

АКТУАЛЬНОСТЬ ПРОБЛЕМЫ ОПРЕДЕЛЕНИЯ ДИОКСИНОВ И ПОЛИХЛОРИРОВАННЫХ БИФЕНИЛОВ (ПХБ) В ПРОДУКТАХ ДЛЯ ДЕТСКОГО ПИТАНИЯ

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РЕЗЮМЕ. Цель. *Анализ современного состояния проблемы определения диоксинов и полихлорированных бифенилов (ПХБ) в продуктах для детского питания и разработка способов подготовки проб для определения этих ксенобиотиков в продуктах питания для детей грудного и раннего возраста.*

Диоксины образуют группу структурно и химически родственных хлорированных трициклических кислородсодержащих ароматических соединений (конгенеров), в которую входят 75 полихлорированных дибензо-пара-диоксинов (ПХДД) и 135 полихлорированных дибензофуранов (ПХДФ). Наиболее токсичны конгенеры диоксинов, у которых атомы хлора наряду с другими положениями обязательно находятся в 2,3,7,8-положениях бензольных колец. Общее их количество 17: 7 конгенеров ПХДД и 10 конгенеров ПХДФ. К диоксинам примыкает группа полихлорированных бифенилов (ПХБ) – хлорированных бициклических ароматических соединений, состоящая из 209 различных конгенеров, 12 из которых имеют пространственную и электронную структуру и проявляют токсикологические свойства, подобные диоксинам, поэтому их называют диоксиноподобными ПХБ (ДП-ПХБ). Кроме того, при проведении мониторинга пищевых продуктов в качестве маркерных выбрана группа из 6-ти ПХБ, которые не проявляют диоксин-подобную токсичность и поэтому относятся не к диоксиноподобным ПХБ (НДП-ПХБ). Таким образом, из общего количества 419 ПХДД, ПХДФ и ПХБ только 35 являются токсикологически значимыми, поэтому эти соединения подлежат контролю в продуктах для детского питания. Для контроля за содержанием суммы диоксинов, суммы диоксинов и ДП-ПХБ и суммы НДП-ПХБ в пищевых продуктах для младенцев и детей от одного до трех лет в Украине максимальные уровни этих соединений на основании приказа МЗ Украины № 368 от 13.05.2013 г. гармонизированы с максимально допустимыми уровнями в пищевых продуктах для детей грудного и раннего возраста в соответствии с Постановлением Комиссии (ЕС) № 1259/2011.

Методы анализа диоксинов и ПХБ. Два инструментальных метода анализа используются для определения диоксинов и диоксиноподобных ПХБ в пищевых продуктах для детского питания: 1) сочетание высокоразрешающей (капиллярной) газовой хроматографии с масс-спектроскопией высокого разрешения (ГХ/МС); 2) сочетание ГХВРЗ с тандемной масс-спектроскопией (ГХ/МС/МС). Для определения не диоксиноподобных (маркерных) ПХБ используется высокоразрешающая (капиллярная) газовая хроматография. Этап пробоподготовки, включающий стадии экстракции и очистки, ключевой при определении диоксинов и ПХБ.

***Выводы.** Разработана стадия подготовки проб с использованием автоматических устройств (жидкостная экстракция под давлением, автоматизированная система очистки экстрактов) и хроматографических колонок для дальнейшего определения в продуктах детского питания массовой концентрации диоксинов и ПХБ. Разработанные процедуры с использованием устройств для автоматической экстракции и очистки полученных экстрактов из проб детского питания позволят в одной пробе в дальнейшем определять ПХДД/ПХДФ, орто-незамещенные, моно- орто-замещенные и маркерные ПХБ.*

***Ключевые слова:** диоксины, полихлорированные бифенилы, детское питание.*

Received 01/27/2020