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Review article

Marcin RÓŻEWICZ, Elżbieta BOMBIK[1], Alina JANOCHA, Katarzyna ŁAGOWSKA[1], Małgorzata BEDNARCZYK[1]

DIOXINS – THEIR INFLUENCE ON HUMAN HEALTH AND THE CONTAMINATION OF PRODUCTS OF ANIMAL ORIGIN

DIOKSYNY – ICH WPŁYW NA ZDROWIE CZŁOWIEKA I SKAŻENIE PRODUKTÓW POCHODZENIA ZWIERZĘCEGO

Department of Animal Nutrition and Feed Management, Siedlce University of Natural Sciences and Humanities, Poland
[1]Department of Animal Reproduction and Hygiene, Siedlce University of Natural Sciences and Humanities, Poland

Streszczenie. Dioksyny stanowią grupę związków o toksycznym działaniu na organizm zarówno ludzi, jak i zwierząt. Z powodu znacznej trwałości mogą one kumulować się w środowisku oraz w kolejnych ogniwach łańcucha pokarmowego. W celu prewencji zdrowia publicznego konieczne jest wykorzystanie środków obniżających emisję tych związków do środowiska naturalnego, prowadzenie kontroli laboratoryjnej pod kątem występowania tych substancji w żywności oraz wprowadzenie regulacji prawnych dotyczących ich bezpiecznej zawartości w produktach żywnościowych oraz paszach dla zwierząt. W pracy przedstawiono aktualny stan wiedzy na temat toksyczności dioksyn, ich zagrożenia dla zdrowia ludzi i zwierząt, działań prewencyjnych oraz uregulowań prawnych w celu ochrony konsumentów przed spożywaniem produktów skażonych dioksynami.

Key words: dioxins, toxicity, contamination.
Słowa kluczowe: dioksyny, toksyczność, skażenie.

INTRODUCTION

Until recently, heavy metals and their compounds were considered the most significant threat in terms of both environmental pollution and human health. However, human activities now often result in the formation of new dangerous compounds referred to as dioxins, as well as their derivatives. Dioxins are the most toxic compounds that have been synthesized by man. This general name involves a range of compounds having two benzene rings connected by one oxygen atom (dibenzofurans – Fig. 2) or two oxygen atoms (dibenzodioxins – Fig. 1). Most dangerous are the tetrachlorodibenzo-p-dioxin (TCDD – Fig. 4), tetrachlorodibenzofuran (TCDF – Fig. 3), polychlorodibenzo-p-dioxin (PCDD), polychlorodibenzofuran (PCDF) and their derivatives.

Corresponding author – Adres do korespondencji: Elżbieta Bombik, Department of Animal Reproduction and Hygiene, Siedlce University of Natural Sciences and Humanities, Bolesława Prusa 14, 08-110 Siedlce, Poland, e-mail: elzbieta.bombik@uph.edu.pl

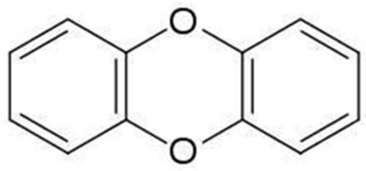

Fig. 1. Dibenzo-p-dioxin (dibenzo-1,4-dioxin) – structural formula
Ryc. 1. Dibenzodioksyna (dibenzo(1,4)dioksyna) – wzór strukturalny

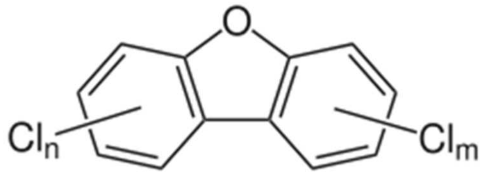

Fig. 2. Dibenzofuran – structural formula
Ryc. 2. Dibenzofuran – wzór strukturalny

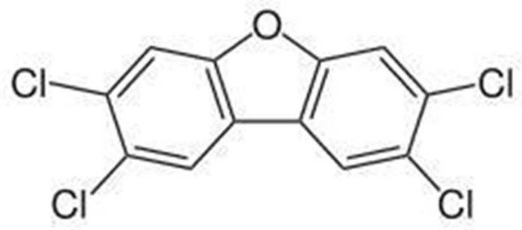

Fig. 3. Tetrachlorodibenzofuran (TCDF) – structural formula
Ryc. 3. Tetrachlorodibenzofuran (TCDF) – wzór strukturalny

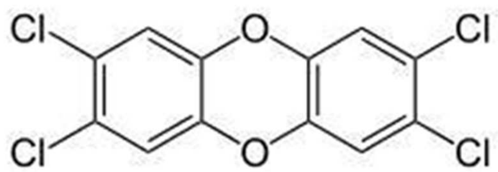

Fig. 4. 2,3,7,8-tetrachlorodibenzodioxin (TCDD) – structural formula
Ryc. 4. 2,3,7,8-tetrachlorodibenzodioksyna (TCDD) – wzór strukturalny

Various industries contribute these substances to the environmental pollution, including producers of chemicals, fertilizers, electronics, paper, steel and metal, glass, and ceramics, but also uncontrolled incineration of domestic wastes, coal, oil, or old tires. The presence of dioxins in the environment and their bioaccumulation in the trophic chain result in a gradual increase in the levels of these dangerous substances. Absorbed by plants, especially those of economic importance, such as grains used to produce feeds for livestock animals, dioxins accumulate in their tissues. Animal products, be it meat, milk, or eggs, may contain considerable concentrations of these compounds. Only after finding dangerous concentration of dioxins in the meat of broiler chickens from Belgium, which had been fed contaminated feed, special attention has been paid to the presence of dioxins in food products. Dioxins alone have never been a target product of any industry. They appeared as by-products and their possible toxic properties were ignored. Ingested even in small amounts, dioxins are deposited and accumulate in fatty tissue. Their toxic effect on the body emerges slowly, without immediate symptoms, which may appear well after several years of dioxins ingestion (Sokołowski 1994).

Due to the contamination of the environment with dioxins, associated with the intensive industrial activity of many countries of the European Union, its institutions have introduced relevant legislation on the monitoring of dioxins and related compounds, both in food products and animal feeds and their components, which is aimed to protect consumers against the health hazard. It is therefore necessary to create appropriate equipment and laboratories to monitor dioxin concentrations. Since costs of such examinations are high, a way to reduce dioxin emission to the environment is being sought.

One method is to raise social awareness of the negative impact of dioxins on health through information campaigns on the sources of dioxin contamination. This is a particularly important issue, since – besides industrial plants – individual households have their part in the pollution, wherever combustion of wastes in stoves takes place. Although recent years have witnessed a reduction in industrial emissions of dioxins and dioxin-like polychlorinated biphenyls (dl-PCBs), which results from severe financial penalties, these highly persistent compounds continue to accumulate on the subsequent levels of the trophic pyramid, still posing a threat to human health. In light of these facts, protecting the human health against the toxic effects of dioxins is the goal of many governments and a priority in the related research areas (Struciński et al. 2011). The problem is the feasibility to determine in the laboratory the levels of dioxins that pose a real threat to human health, including the impact of these compounds on various organs and their functions, including the reproductive system. This issue results from the difficulty of finding the appropriate animal model which could be used to determine the level of dioxins that is safe for humans. This is due to the diversity of biochemical reactions induced by TCDD, ample differences between model animals in the susceptibility for these compounds, and the translation of results to toxicity degree and life-threatening level for humans.

The aim of the study was to present the current state of knowledge on the toxicity of dioxins, the threat they pose to both human and animal health, as well as the preventive measures and regulations aimed to protect consumers against products contaminated with dioxins.

DIOXINS AS TOXIC COMPOUNDS

This group of compounds, commonly referred to as dioxins, has been designated due to the similarities in their toxic, physical and chemical properties. First detected in the late 1950s, dioxins were discovered relatively recently, which is related to the invention of the first methods of their analysis (Piskorska-Pliszczyńska 1999). Cases of contamination of food products with these compounds raised a legitimate public concern in terms of food safety (Tlustos 2008; Piskorska-Pliszczyńska and Warenik-Bany 2013). The interest in dioxins among the researchers is also due to the omnipresence of dioxins in the environment and their long-term persistence (up to 30 years in the human body), as well as due to the high toxicity to humans and animals (Colborn et al. 1993; Birnbaum 1994; Struciński et al. 2000; Makles et al. 2001; Van der Bergh et al. 2006; Piskorska-Pliszczyńska 2011; Biernacki et al. 2015). Dioxins refer to a group of chlorinated aromatic compounds, exhibiting exceptionally high thermal stability and chemical resistance to oxidation and biological degradation; the compounds include polychlorinated and polybrominateddibenzo-p-dioxins and dibenzofurans. Despite some differences, dioxins have the following common features:

- the same sources and processes of formation,
- similar physico-chemical and toxic properties,
- mutual coexistence,
- similar methods of determination.

The primary skeleton for the formation of these compounds is diobenzo-p-dioxin. Combustion of products and wastes containing diobenzo-p-dioxin produces its derivatives of similar toxicity against human and animal organisms. It is a colorless, crystal-forming solid with a melting point in the range from 88°C to 332°C. Dioxins are hydrophobic, which makes them difficult to leach from the surface of the soil to its deeper layers; this contributes to its accumulation in the environment. However, the molecular structure makes them lipophilic, hence they are well soluble in non-polar solvents, such as fats or oils. Therefore dioxins entering the body easily accumulate in the adipose tissue, which in turn makes it difficult to get rid of them (Fig. 5).

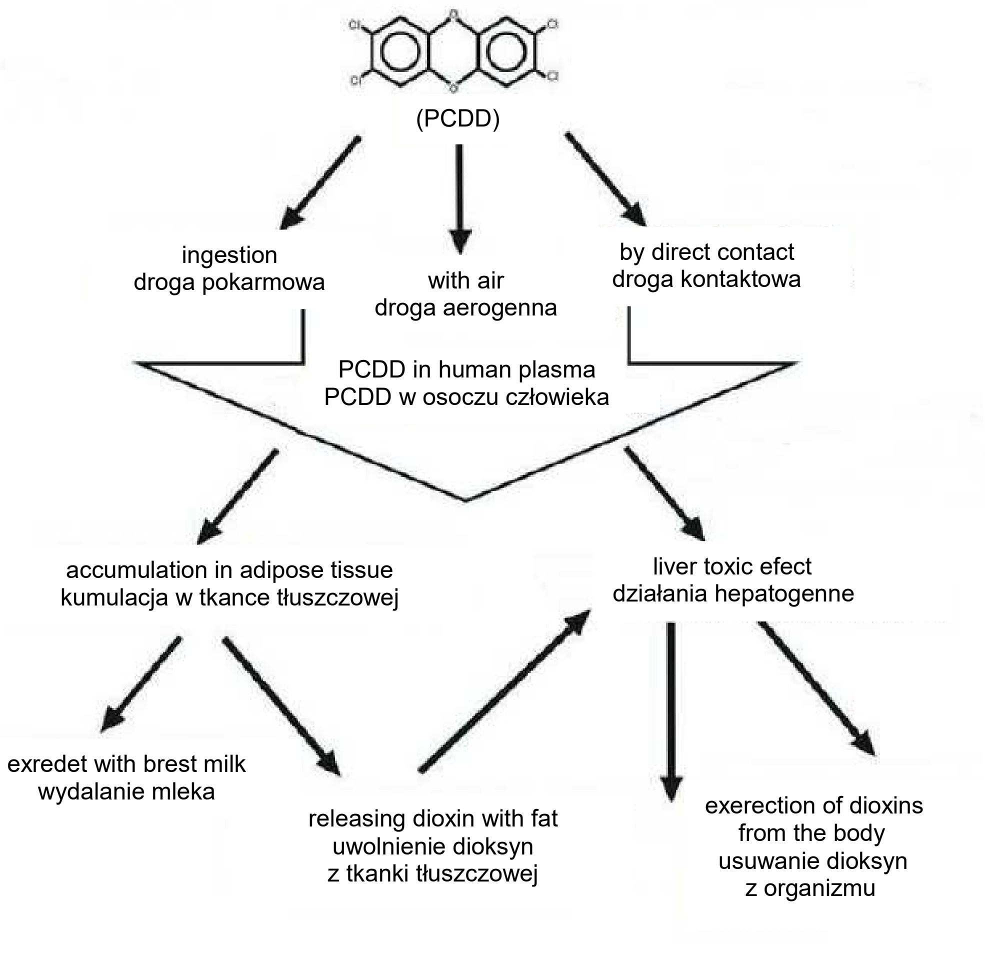

Fig. 5. Routes of adsorption of dioxin in the body
Ryc. 5. Drogi wchłaniania dioksyn do organizmu

Showing no toxicity in the beginning, the compounds gradually increase in the concentration. They also reveal a high level of resistance against oxidants and acids, as well as high temperatures. Only ultraviolet radiation or very high temperatures above 1200°C may be destructive to dioxins (Piskorska-Pliszczyńska 1999; Dudzińska et al. 2001). Due to their properties, the toxicity of dioxins is very high. The toxicity of individual compounds within this large group is varied, though. This is due to the differences in the structure of the molecules, the number of chlorine or bromine atoms they contain and their position in the aromatic ring. The most toxic to living organisms is probably 2,3,7,8-tetrachlorodibenzo-p-dioxin (Dudzińska et al. 2001; Schecter et al. 2006; Biernacki et al. 2015). Due to the large number of compounds belonging to the dioxin group and their varying degree of toxicity, it was necessary to determine the scale of their toxicity. The toxicity equivalent factor (TEF) serves as such a determinant, which expresses dioxin toxicity in relation to the most toxic form of dioxin, TCDD. A TEF value for a particular compound is also determined on the basis of biological effects observed *in vivo* and *in vitro*. These include the median lethal dose (LD_{50}), weight loss, thymus atrophy, activation of hepatic aromatic hydrocarbons hydroxylase, inhibition of gluconeogenesis and increase in the concentration of tryptophan in the blood (Makles et al. 2001; Struciński et al. 2011). Although dioxins are common in the environment, they do occur in the pure form, but always as a mixture of different substances; therefore the TEF is used to designate the toxic equivalent (TEQ), which is the sum of the products of the concentrations of different congeners (chemicals related by structure or functions) and their TEFs. This method is used to determine the total toxicity of sample mixtures of dioxins and furans (Ahlborg et al. 1992; Sokołowski et al. 1994; Weisglas-Kuperus 1998; Beard et al. 1999; EU Commission Regulation No 1259/2011). Struciński et al. (2011) also point to the varied impact of dioxins in various animal species, even those belonging to one family. The authors give an example of two common laboratory species, namely the lethal dose of the most toxic TCDD for a guinea pig is 0.6 mg/kg, whereas the dose to kill a hamster must be 5000 times higher. There is no possibility of testing dioxins on humans. However, the well-known case of poisoning former Ukrainian President Yushchenko using this compound indicates that the theoretical standard toxicity – specified for humans at the level 1–4 pg/kg body weight – was exceeded 20 thousand times in this particular case. We cannot, however, consider that value as a limit, since it was a single case, and there may also be different individual predispositions of the body to cope with such high concentrations of TCDD (Całkosiński et al. 2011; Żukiewicz-Sobczak et al. 2012).

TOXICITY TO HUMANS AND ANIMALS

For bioethics reasons, there is no possibility of direct and deliberate experimentation on the impact of dioxins or dose testing on humans, therefore the research in this field is carried out on model animals. Due to varied, species-related responses, it is difficult to directly relate the effects or levels to other animals and the human body. A direct toxic effect of dioxins in human organism can only be observed in cases of accidental poisoning. Large, single doses may be more toxic, however, than a long-lasting exposure to small doses. It seems also reasonable to study the possible so called hormetic effect. This response is defined as the mobilization of repair and detoxification mechanisms of the body to reach the level that reduces the toxic impact and neutralizes the damage that normally occurs in every organism. Dioxins cause different effects in various species of experimental animals; these include carcinogenic activity (in the liver, kidney and thyroid), immunotoxicity, embryo- and fetotoxicity, teratogenic effects, hepatotoxicity, and disturbances in the reproductive system function and endocrine system homeostasis (Sokołowski 1994; Piskorska-Pliszczyńska 1999; Giacomini et al. 2006). Although doses of dioxins used in experiments on animals were significantly lower than those to which man is exposed in everyday life (2–3 times lower), the results of epidemiological studies allow concluding with high confidence that environmental exposure to dioxins (especially during the pre- and postnatal life) may adversely affect the health and disturb numerous physiological processes in the human body. According to Słowińska et al. (2011), in 1997 the International Agency for Research on Cancer (IARC) recognized TCDD as the most toxic substance in the group of dioxins and classified it as group 1 carcinogen, ie. a substance with evident carcinogenic impact for humans. In 2009, this group was extended by other dioxins, 2,3,4,7,8--pentachlorodibenzofuran and 3,3',4,4',5-pentachlorobiphenyl (PCB 126) representing dioxin--like polychlorinated biphenyls, dl-PCBs (Mocarelli et al. 2011). However, according to Tsai et al. (2007), these compounds are directly toxic to genes only after exceeding a certain level of concentration in the body. Below this threshold, their negative impact is undetectable. It is believed that these compounds adversely affect the human reproductive system, primarily by mimicking the action of sex hormones and disrupting their homeostasis, regulation and secretion through a negative feedback in the hypothalamic – pituitary – peripheral gland axis, which particularly impair ovarian and testicular function (Beard et al. 1999). Due to their molecular structure similar to steroid hormones, dioxins target particularly such organs as thyroid, female and male gonads, endometrium and other organs that produce steroid hormones. As a result, their presence in the animals or human body influence the synthesis, secretion, transport, and removal of hormones from the system. The negative effects of dioxins also include destruction of the bonds between hormones, produced and released to the circulation, and their respective receptors. The toxic effects of dioxins can be much more dangerous to developing fetuses. Organic chlorine compounds are transferred from mother's body to the fetus through the placenta and the baby receives them from their mother's milk.

In studies on rats, Całkosiński et al. (2003, 2004) reported that dioxins given to pregnant females were also toxic to their fetuses, and the toxins affected their gonadal development. The authors associated the destructive effects of dioxins on the reproductive organs with changes in estrogen levels in the blood of rats. One of the symptoms observed in humans, who are under systemic, extensive exposure to dioxins, eg. in their work environment or from food, is chloracne, first described in 1899. The disease is manifested by a significant thickening of the horny layer of the epidermis and its hyperplasia. It arises as a result of dysfunction of the sebaceous glands, which become thickened with their infundibula clogged by comedos of sebum. This symptom, however, is delayed and appears after longer exposure lasting several months (Słowińska et al. 2011). Due to the short life span of most livestock animals, symptoms of dioxin poisoning are difficult to detect or remain undetected. Most often, the presence of dioxins in the tissues is detected as a result of additional analysis, for example after the slaughter or in the consequence of people poisoning incidents.

Examinations of feed components for dioxins content are costly, yet necessary. Compliance with the requirements in this respect is needed in order to have safe food products that contain as little dioxins as possible. According to Commission Regulation (EC) No 277/2012 of 28 March 2012, maximum dioxin content, calculated as the sum of PCDD and PCDF, expressed in ng WHO PCDD/F – TEQ/kg in feed components of plant and mineral origin and feed additives, such as kaolin clay, vermiculite, as well as in compound feeds, may be 0.75 ng/kg, with the exception of compound feed for pet animals and fish, in which the maximum content should not exceed 1.75 ng/kg. In feed components of animal origin, including animal fat, milk fat and egg fat, dioxins concentration cannot exceed 1.5 ng/kg, in fish oil: 5 ng/kg, in fish and other aquatic animals and products derived therefrom: 1.25 ng/kg, in hydrolyzed fish protein: 1.75 ng/kg, and in premixes: 1 ng/kg. The total concentration of dioxins and dioxin-like PCBs in feed components of plant origin may not exceed 1.25 ng/kg, and in feed additives, prefixes and compound feeds: 1.5 ng/kg. Maximum concentration of dioxins in feed components derived from terrestrial animals, including milk and dairy products, eggs and egg products is 1.25 ng/kg, whereas in animal fat, including milk fat and egg fat, it may not exceed 2 ng/kg.

The vast majority of examined feed components are of good quality and do not exceed the concentration permitted by the regulated standards. In about 1400 analyzed samples of commercial feeds for livestock animals, only 27 feeds exceeded the required levels, which accounted for 1.9% of all samples tested. Permanent monitoring also allows detection of trends as to which materials can be expected to exceed the acceptable level of dioxin content, and these are mainly vegetable oils, fish oil, and mineral supplements (Piskorska-Pliszczyńska et al. 2013). Also, research by Cybulska et al. (2012) confirm the good quality of Polish feed components in terms of compliance with the standards of the total concentration of compounds belonging to the group of dioxins, and their average concentration in the examined feed raw materials does not exceed the half of the maximum required by legal standards. Also, according to Korol and Matyka (2000), the results of the tests of dioxin content in feeds show that the hazard is low, but the authors also point to the need for constant monitoring of dioxin levels taking into account the standards and regulations introduced by the European Union.

DIOXINS IN FOOD AS A THREAT TO HUMAN HEALTH AND THE IMAGE OF POLISH FOOD PRODUCTS

Poland is the European leader in the production of many food products, and occupies leading positions especially in the production of poultry as well as milk and dairy products. Food produced in our country is largely exported, both to the internal market of the European Union and the other markets of the world. This production and its exports have a significant contribution to the overall GDP of our country. From January to May 2015, Polish exports of agri-food products amounted to 9.3 billion euros. Compared to the same period of 2014, there is an increase by about 480 million euros, or 5.5% (Eksport żywności nadal rozpędzony, http://www.minrol.gov.pl). Such a significant role of Poland in the European and global food markets results in the situation that many countries, in order to protect their domestic markets and farms, make use of even trivial reasons to discourage consumers from purchasing imported agricultural products; some goverments have reached for measures such as an embargo on imports. Even incidental cases when dioxins in foodstuffs have been detected are publicized by the media, which effectively discourage consumers from buying not only the given product, but also other foods imported from the country of its origin. Considering these facts, it is essential to fully comply with all the legal and sanitary procedures and requirements, in order to prevent possible adverse economic consequences, including compromised country's image, that may negatively affect the perception and sales of Polish products.

In recent years, a significant scientific interest has been focusing on the biological impact of dioxins, as well as on their presence in the food chain. Introduced into the environment, dioxins are subject to the general rules that underly spreading of the substances in the biosphere. Their emission in the consequence of waste incineration results in spreading dioxins with dust and smoke over large distances and areas. Next, falling on the soil, they contaminate it, and fodder plants absorbing dioxins primarily the initial level of the food chain. Animals grazing on dioxin-contaminated soils are directly exposed to the absorption of dioxin through their inhalation and ingestion via the digestive system. Then dioxins accumulate in the fatty tissue of the animals and are transmitted to the food products derived from them, such as eggs, milk and dairy products. Contaminated is also the meat of these animals. Being at the top level in the food chain, man ingests food from vegetables or animal origin along with considerable amounts of dioxins. Direct eventual dioxin levels depend on the daily dose taken by the animal and the time of their accumulation in the body. Dioxin contamination is monitored using different methods, such as chemical, biological and toxicological monitoring. Biological monitoring consists in observing changes of dioxins in living organisms, including humans. Organic chlorine compounds are transferred from mother to fetus through the placenta and, next, the baby receives them from their mother's milk. Chemical monitoring involves laboratory methods for identification and measuring the content of specific compounds belonging to the dioxins in the environment, food products and feed components.

Finally, toxicological monitoring includes diagnosis and assessment of dioxin poisoning affecting professional groups of people exposed to the toxins (Makles et al. 2001). The term monitoring is understood as the actions aimed ato inspection, identification and determination of the degree of threat of a possible dioxin contamination. Due to their lipophilic nature, the compounds of the dioxins group most often accumulate in products having a significant content of fat, including oils, as well as those of animal origin, such as milk and dairy products and eggs. Cebulska et al. (2012), using the biological method, determined the content of dioxins and furans in milk and dairy products, such as whole and skimmed milk powder, cheese and butter (Table 1).

Table 1. The content of dioxins-group compounds in milk and dairy products
Tabela 1. Zawartość substancji z grupy dioksyn w mleku i produktach jego przerobu

		Rodzaj badanego materiału – Product type				
		wholemilk-powder mleko pełne w proszku	butter masło	cheese sery	raw milk mleko surowe	skimmedmilk-powder mleko odtłuszczone w proszku
Analyzed compounds Związki badane		pg WHO-TEQ/g of fat – pg WHO-TEQ/g tłuszczu				pg WHO-TEQ/g of product pg WHO-TEQ/g produktu
PCDD + + PCDF	range – zakres	0.07–2.22	0.05–2.15	0.07–1.83	0.01–2.15	0.06–1.99
	mean ± LSD średnia ± SD	0.85 ± 0.61	0.86 ± 0.58	0.90 ± 0.50	0.18 ± 0.33	0.80 ± 0.57
dl-PCB	range – zakres	0.10–1.62	0.06–2.05	0.06–1.01	0.03–2.28	0.10–1.92
	mean ± LSD średnia ± SD	0.56 ± 0.37	0.45 ± 0.39	0.47 ± 0.24	0.21 ± 0.31	0.63 ± 0.47
Σ PCDD + + PCDF + + dl-PCB	range – zakres	0.31–2.85	0.35–3.73	0.24–2.49	0.05–3.20	0.40–3.55
	mean ± LSD średnia ± SD	1.41 ± 2.85	1.31 ± 0.83	1.38 ± 0.57	0.39 ± 0.54	1.43 ± 0.77

Source – Źródło: Cebulska et al. (2012).

The conclusion of the study was that dioxins, furans and dl-PCBs were present in low concentrations, not exceeding the permissible limits laid down in the Regulation of the European Commission (No. 1259/2011) (the limit for the sum of PCDD and PCDF is 3 pg WHO-TEQ/g fat, limit for the sum of PCDD, PCDF and dl-PCBs: 6 pg WHO-TEQ/g fat). Of the 218 samples tested, the vast majority (198) contained dioxin levels well below 50% of the required limit. Piskorska-Pliszczyńska et al. (2015), who studied dioxin levels in eggs – a product commonly used in food safety research – and evaluated the impact of the management system of their laying hens, found that the lowest level of dioxins was present in eggs coming from hens managed under – in this sequence – industrial, on bedding and in cage system of farming. The highest levels of dioxins were found in the eggs obtained from free-ranging hens and organic system of farming, in which the concentration of dioxin was two times higher than in eggs from industrial egg farms (Table 2).

Table 2. The content of dioxins, furans, dl-PCBs and NDL-PCBs in chicken eggs
Tabela. 2. Zawartość dioksyn, furanów, dl-PCB oraz NDL-PCB w jajach kurzych

Laying hens housing system System chowu niosek	PCDD/PCDF xav. ± SD min–max	dl-PCB xav. ± SD min–max	PCDD/PCDF/dl-PCB xav. ± SD min–max	Level exceeding the standards of EU Regulation No. 277/2012 and No. 1259/2011 Poziom przekroczenia normy Rozporządzenia UE nr 277/2012 i nr 1259/2011
Battery Bateryjny n = 72	0.60 ± 0.42 0.32–0.76	0.19 ± 0.16 0.12–0.61	0.79 ± 0.53 0.44–0.91	0
On bedding Ściółkowy n = 13	0.40 ± 0.10 0.30–0.60	0.17 ± 0.06 0.14–0.30	0.57 ± 0.12 0.44–0.77	0
Freeranging Wolnowybiegowy n = 117	1.38 ± 3.05 0.30–29.32	0.37 ± 0.70 0.13–7.17	1.76 ± 3.21 0.44–29.84	10 (9%)
Organic Ekologiczny n = 23	1.66 ± 1.80 0.32–8.21	0.48 ± 0.38 0.14–1.42	2.14 ± 2.13 0.46–9.63	4 (17%)

The results of quantification for PCDD, PCDF and NDL-PCBs are presented in pg WHO-TEQ/g of fat.
Wyniki kwantyfikacji dla PCDD, PCDF i NDL-PCB są przedstawione w pg WHO-TEQ/g tłuszczu.
Source – Źródło: Piskorska-Pliszczyńska et al. (2015).

The authors concluded that such differences in dioxins levels may result from differences in exposure to these compounds in various management systems of hens. Hens kept in a free range system, in addition to the feed ration that could be a source of dioxins, can also ingest dioxin-contaminated invertebrates, as well as green forage from contaminated soil (Fig. 5). Layers in the farming industry may only obtain a dose of dioxin with the feed. Since feed components fed to animals may contain significant amounts of dioxins, there is a need to control their concentration. The total elimination of dioxins from feed components, due to their high persistence, is not possible, but it is important to reduce their levels to a minimum and to comply with the standards in this respect, which will also ensure the safety of food products derived from animals. As indicated Piskorska-Pliszczyńska and Małagocki (2013), the products derived from ruminants are more exposed to contamination by dioxins than poultry or pork products, since their diets are dominated by roughage. In the case of poultry and pigs, shorter time of rearing cycle and feeding industrial feeds also result in a lower dioxin content in their meat.

LEGAL STRATEGY OF THE EUROPEAN UNION TO REDUCE HAZARDS AND PROTECT CONSUMERS FROM PRODUCTS CONTAMINATED WITH DIOXINS

Because of the omnipresence of environmental pollution with dioxins and due to cases of contamination of food products with these compounds, the European Union – as a political and economic community fostering the free internal movement of goods – undertook measures aimed to reduce the exposure of people and animals to dioxin poisoning hazard. One of the pillars of the adopted strategy is to reduce dioxin emissions from industrial plants. Another aspect is to control the food chain by monitoring the bioaccumulation of dioxins in animals and humans (Piskorska-Pliszczyńska and Warenik-Bany 2013). Extending the Community by new members caused concern whether this process would not increase the exposure of European consumers to eating foods with too high dioxin content. These concerns arose from increased dioxin emissions in these countries and outdated production methods and technology in the industry. Hence the need for regulations that would address the issue of dioxins by setting two priorities: (1) limitation of emissions of dioxins into the environment and (2) control of their penetration into the food chain and bioaccumulation in its subsequent elements.

Therefore, on October 24, 2001, the official document operatively called "dioxin strategy" was formulated. This was followed by the issuance of subsequent legislative solutions put in force in all the EU member countries. The provisions were aimed to determine the acceptable levels of dioxins in food products, exceeding of which would trigger certain actions and administrative measures (EU Commission Regulation No. 1259/2011, 277/2012, 589/2014). The documents also presuppose continued efforts to reduce dioxin content in food products, and thus also to reduce their acceptable levels. A range of directives, regulations and recommendations concerning dioxins have been introduced since 2001. The governments and authorized institutions in the member states are responsible for the implementation of the provisions. This is done through food checks and inspections carried out by food safety administration, as well as inspections of feed for farm animals (EU Commission Regulation No. 277/2012). The regulations concern the ban on the marketing of products containing high concentrations of dioxins, exceeding the legal limit. In the light of these provisions, mixing products contaminated with excessive levels of dioxin with those that meet the standards is unacceptable. Responsibility for the quality and safety of food exports is on the agencies of the country of origin. Inspection, on the other hand, is carried out by the importer state on both external and internal EU borders, but also on arrival to the country of destination. The inspection procedures alone consists in random sampling of the products and analyzing them for dioxin concentration.

CONCLUSION

In conclusions, it should be stated that dioxins are a group of compounds with toxic effects on the body of both humans and animals. Due to their enormous persistence, dioxins may accumulate in the environment and organisms on each level of the trophic chain. The member states of the European Union take preventive measures and introduce regulations in terms of dioxins levels in food products and animal feed, which should contribute to the protection of consumers from the consumption of products contaminated with dioxins.

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Abstract. Dioxins represent a group of compounds that are toxic to both humans and animals. Due to their enormous persistence, dioxins accumulate in the environment and organisms on each level of the food chain. For the sake of public health safety, all necessary measures should be taken in order to reduce the emission of dioxins to the environment. Laboratories should examine food for the presence of these substances and legal regulations on food safety standards should be introduced in terms of their tolerable concentrations in food products and animal feed. The aim of the study was to present the current state of knowledge on the toxicity of dioxins, how they threat human and animal health, what preventive measures and regulations are at place to protect consumers against products contaminated with dioxins.