Frequently asked questions about dioxins and PCBs in food

BfR FAQ of 4 December 2018

Dioxins and polychlorinated biphenyls (PCBs) are environmental contaminants which accumulate primarily in fatty food of animal origin due to their lipophilic properties. Dioxins are not purposely manufactured, they occur as by-products during combustion processes in particular. They can also be formed during forest fires and volcanic eruptions.

By contrast, PCBs have been used for a variety of purposes, for example as non-combustible liquids in heat exchangers, transformers and electrical capacitors or as softening agents in paints, sealing compounds and plastics. Placing PCBs on the market has been prohibited in most countries since the 1980s.

People take in dioxins and PCBs mainly through animal-based foods.

What are dioxins?

The term "dioxins" refers to two categories of differently chlorinated compounds consisting of 75 polychlorinated dibenzo-p-dioxins (PCDD) and 135 polychlorinated dibenzofurans (PCDF). Dioxins (PCDD/F) have similar chemical and physical properties. The 17 compounds chlorinated in 2,3,7,8 positions are particularly toxic and simultaneously persistent. They accumulate in the fatty tissue of animals and humans.

How are dioxins formed?

Dioxins are not manufactured for specific purposes, they result as by-products during combustion processes, in particular when organic carbon compounds are burned in the presence of chlorine and temperatures of at least 300 degrees occur. They can also be formed during forest fires and volcanic eruptions. Dioxins adhere to particles of dust and are spread in the environment in this way. They are not and have never been produced purposely (except in small amounts for scientific purposes).

What are polychlorinated biphenyls (PCBs)?

The group of polychlorinated biphenyls (PCBs) includes 209 substances which differ in the number and position of the chlorine atoms on the biphenyl and have different (toxic) properties.. Some PCB congeners have a molecular structure similar to that of dioxins and comparable biological effects. They are therefore referred to as dioxin-like PCBs (dl-PCBs). The remaining PCB congeners do not have dioxin-like properties, have a different toxicological profile and are referred to as non-dioxin-like PCBs (ndl-PCBs).

What are PCBs used for?

PCBs have been used for a variety of purposes, for example as non-combustible liquids in heat exchangers, transformers and electrical capacitors or as softening agents in paints, sealing compounds and plastics. Placing PCBs on the market has been prohibited in most countries since the 1980s.

What effects do dioxins and dl-PCBs have on health?

Dioxins and dioxin-like PCBs (dl-PCBs) are very long-lasting compounds. They accumulate in fatty tissue and are degraded very slowly. Chronic effects observed in animal experiments are impairments to reproductive functions, the immune system, the nervous system and the hormonal balance. In these animal experiments, male rats demonstrated the greatest sensitivity to dioxins. The development of the immune system and genitals were identified as very sensitive endpoints in rats exposed to dioxins prenatally (WHO 2002). Furthermore, the liver

and the thyroid were identified as the most sensitive target organs to dioxin exposure. In a statement, the European Food Safety Authority (EFSA) views effects on sperm quality as the most sensitive endpoint. This is the strongest effect that occurs at the lowest dose. It is assumed that some dioxins and dl-PCBs may increase the risk of cancer.

Acute effects caused by high doses of dioxins or dl-PCBs in humans have only been described after industrial accidents, the intake of high concentrations in the workplace or intentional poisoning. In these cases, the most frequent effects are long-lasting inflammatory skin changes referred to as "chloracne". Changes to clinical-chemical parameters (in particular, an increase in concentrations of triglycerides, cholesterol and transaminases in the blood) also indicate liver damage or changes in fat metabolism.

In addition to the concentrations of dioxins in foods, the quantities in which the respective foods are usually consumed must always be taken into consideration when estimating consumer exposure. Contamination with dioxins should be minimised further for consumer health protection reasons. In this respect, unnecessary and avoidable contamination is unacceptable. In November 2018, the European Food Safety Authority (EFSA) derived a new health-based guidance value for dioxins and dioxin-like polychlorinated biphenyls (dl-PCBs). The tolerable weekly intake (TWI) for dioxins and dl-PCBs was reduced from 14 picograms (14×10^{-12} grams) to two picograms per kilogram of body weight. The TWI value refers to the amount of a substance ingested every week over a lifetime at which health impairments in humans are not to be expected.

Through which foods are dioxins and PCBs ingested?
Because dioxins and PCBs occur everywhere in the environment, transfer to the food chain cannot be prevented. Farm animals take in these contaminants from particles of soil, in particular when pecking or when the particles of soil adhere to their feed. Intake directly via feed is also possible. Dioxins accumulate in the fatty tissue of animals, which is why foods of animal origin contain higher levels than plant-based foods. This means that humans mainly take in dioxins through foods such as meat, fish, eggs and milk, as well as products made from these foods.

What is meant by WHO-PCDD/F-TEQ, WHO-PCB-TEQ and WHO-PCDD/F-PCB-TEQ?
The toxic equivalency factor (TEQ) system takes account of the different toxicities of the individual compounds. Toxic equivalency factors (TEF) assign a ranking to the different congeners. The toxicity of the individual substances is compared with the most toxic compound, the 2,3,7,8-TCDD, better known as "Seveso dioxin". With multiplication by the relevant toxic equivalency factor, the concentrations of the individual compounds are first calculated as toxic equivalencies. Adding these equivalencies then provides the total concentration of toxic equivalencies which corresponds to the concentration of pure 2,3,7,8-TCDD in terms of its effect.

WHO-PCDD/F-TEQ is the sum of the toxic equivalencies of the 17 most toxicologically significant dioxins and furans.

WHO-PCB-TEQ is the sum of the toxic equivalencies of the 12 dl-PCBs. Like dioxins, these dl-PCBs are assigned TEFs which classify these PCB congeners according to their toxicity as compared to 2,3,7,8-TCDD.

The sum of WHO-PCDD/F-TEQ and WHO-PCB-TEQ is referred to as the total dioxin equivalency (WHO-PCDD/F-PCB-TEQ). Maximum levels for WHO-PCDD/F-TEQ and for WHO-

PCDD/F-PCB-TEQ are listed in the Annex, Section 5 of Regulation (EC) No. 1881/2006 (as amended) adopted by the European Commission on 19 December 2006.

In its Scientific Opinion from 2018, the Panel on Contaminants in the Food Chain (CONTAM) of the European Food Safety Authority (EFSA) recommends reviewing the current toxic equivalency factors (TEQ) of the WHO with consideration of new in vivo and in vitro data (https://www.efsa.europa.eu/sites/default/files/event/181113-ax10.pdf).

What tolerable intake levels apply to dioxins?
The tolerable daily intake (TDI) is the amount of a substance ingested every day over a lifetime at which no negative effects on health in humans are to be expected. As a rule, the tolerable weekly intake is used for toxic, long-lasting substances that accumulate in the body.

In 2000, the WHO derived a TDI in the range of one to four picograms WHO-PCDD/F-PCB-TEQ per kg body weight. One picogram (pg) is equal to one million-millionth (10^{-12}) of a gram.

In 2001, the Scientific Committee on Food (SCF) of the European Union (EU) derived a tolerable weekly intake (TWI) of 14 pg WHO-PCDD/F-PCB-TEQ per kg body weight.

In 2001, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) derived a provisional tolerable monthly intake (PTMI) of 70 pg WHO-PCDD/F-PCB-TEQ per kg body weight per month.

In November 2018, the European Food Safety Authority (EFSA) derived a health-based guidance value for dioxins and dioxin-like polychlorinated biphenyls (dl-PCBs). According to this, the tolerable weekly intake (TWI) for dioxins and dioxin-like polychlorinated biphenyls is two picograms (2×10^{-12} grams) per kilogram of body weight.

Why do different maximum dioxin levels apply to different foods?
Maximum levels are prescribed in the EU for some food categories (such as hen's eggs). Maximum levels are defined mainly based on the unavoidable contamination of foods in a category with dioxins from the environment, the so-called background concentration. The intention is that foods within the category (e.g. hen's eggs) with particularly high contamination are kept off the market. Maximum levels are thus not based primarily on toxicological reasons, but on the principle of minimising total exposure.

The maximum levels for specific contaminants in foods are listed in the Annex, Section 5 of Regulation (EC) No. 1881/2006.

Why do the maximum levels for dioxins in fish apply to wet weight, while the maximum levels for other animal-based foods apply to the fat content?
In most cases, the maximum levels for dioxins in foods apply to the fat content of the foods because dioxins accumulate in the fatty tissue of the animals from which the food is derived.

Fish and fish products are an exception to this rule. Here, the maximum levels apply to the wet weight. Because different types of fish have very different fat contents, wet weight is preferred here to allow greater comparability.

What is the level ofintake of dioxins in Germany?
According to analysis results from the years 2000 to 2003, the average daily intake of dioxins and PCBs (WHO-PCDD/F-PCB-TEQ) through food in Germany was approx. two picograms

WHO-PCDD/F-PCB-TEQ per kg body weight per day. Environmental contamination with dioxins has decreased significantly in the last number of years. The reduction in dioxin intake is reflected also in the falling dioxin levels in breast milk (Federal Health Bulletin, August 2018): https://link.springer.com/article/10.1007/s00103-018-2764-5).

What happens when the maximum levels are exceeded?
Foods exceeding the legally prescribed maximum level are not permitted to be placed on the market. Concentrations higher than the maximum levels in foods in the short term do not necessarily mean that the consumption of these foods is associated with a health risk. With respect to dioxins and PCBs, maximum levels are not based primarily on toxicological reasons.

What happens when the tolerable intake level is exceeded?
Moderately exceeding the tolerable intake level in short term does not automatically pose a risk to health. With regard to substances such as dioxins and PCBs, it is the total amount in the body, i.e. the body burden, and not the dose ingested daily that determines effects on health. Dioxins and PCBs accumulate in the body. Due to the existing concentrations in foods, everyone takes in traces of dioxins and PCBs daily (background concentration). In the long term, this daily intake should not be above the tolerable intake level so that a critical body burden is not reached, even in old age. However, moderately exceeding the tolerable intake level in short term has a negligible effect on the existing body burden, meaning that health impairments are unlikely. Nevertheless, in principle, violations of the tolerable intake level resulting from avoidable exposure exceeding the maximum levels are not acceptable.

This text version is a translation of the original German text which is the only legally binding version.