Dioxin Contamination in Food

Bayreuth, Germany, from September 28 to October 1, 2000


1 Danish Veterinary and Food Administration, Institute of Food Research and Nutrition, Morkhoj Bygade 19, DK-2860 Soborg Copenhagen, Denmark
2 PD Consulting, Round House Cottage, Lechlade, Glos GL7 3EE, United Kingdom
3 UNEP Chemicals, 11-13, chemin des Anémones, CH-1219 Châtelaine (GE), Switzerland
4 Chemisches Landes- und Staatliches Veterinäruntersuchungsamt, Sperlischestraße 19, D-48151 Münster, Germany
5 Institute of Environmental Medicine, Karolinska Institutet, Box 210, S-171 77 Stockholm, Sweden
6 Ökometric GmbH, Bernerkerstraße 17-21, D-95448 Bayreuth, Germany
7 University of Bayreuth, D-95440 Bayreuth, Germany
8 TU Delft, Department of Biotechnology, Kluyver Laboratory, Julianalaan 67, NL-2628 BC Delft, The Netherlands
9 Chemisches und Veterinäruntersuchungsamt Freiburg, Bissiersstraße 5, D-79114 Freiburg, Germany
10 Centers for Disease Control and Prevention (CDC), Toxicology Branch (F-17), 4770 Buford Hwy, MS-F-17, Chamblee, GA 30341, USA
11 University of Amsterdam, Dept. of Environmental and Toxicological Chemistry, Nieuwe Achtergracht 166, NL-1018 WV Amsterdam, The Netherlands
12 ERGO Forschungsgesellschaft mbH, Geierstraße 1, D-22305 Hamburg, Germany
13 CID-CSIC, Mass Spectrometry Laboratory, Jordi Girona 18-26, E-08034 Barcelona, Spain
14 Umweltbundesamt, Spittelauer Lände 5, A-1090 Wien, Austria
15 European Commission – JRC Ispra, Environment Institute, Soil and Waste Unit, T.P. 290, I-21020 Ispra (Varese), Italy
16 National Public Health Institute, Division of Environmental Health, P.O. Box 95, FIN-70701 Kuopio, Finland
17 European Commission – DG Joint Research Centre, Institute for Health and Consumer Protection, P, 260, I-21020 Ispra, Italy

Corresponding author: Dr. Heidelore Fiedler, UNEP Chemicals, 11-13, chemin des Anémones, CH-1219 Châtelaine (GE), Switzerland; e-mail: hfiedler@unep.ch

Abstract. Dioxin and PCB monitoring programs for food and feeding stuff in most countries of the world, including many European Countries are currently inadequate. Better control of food production lines and food processing procedures is needed to minimize entry of dioxin to the food chain and will help to avoid dioxin contamination accidents. This would also improve the ability to trace back a possible contamination to its source. European guidelines for monitoring programs should be established to ensure comparable and meaningful results. These guidelines should define the minimum requirements for the design of monitoring programs, analytical methods, and quality assurance. Though data from Northern Europe shows that the general population exposure to dioxin and PCB has decreased during the last ten years these compounds continue to be a risk of accidental contamination of the food chain. The most prominent recent example is the Belgian dioxin contamination of feeding stuff in 1999. The Belgian dioxin contamination was not detected due to dioxin monitoring programs but by their direct biological effects seen in animals. Four other cases of dioxin contamination have been detected in Europe since 1997 due to local monitoring programs. One of them (citrus pulp pellets 1998) was in a much larger scale than the Belgian dioxin contamination. The general population’s exposure to dioxins and PCBs is still in the same range (1-4 pg WHO-TEQ/kg body weight and day) as the recently revised WHO tolerable daily intake (TDI). There is concern that short-term high level exposure to dioxins, furans, and PCB may cause biological effects on the human fetal development and further research is required. Further actions to control sources building on considerable advances already made in many countries may need to be supplemented by measures to prevent direct contamination of feeding stuff or food to reduce general population exposure further.

Keywords: Analysis; dioxins and furans; food contamination; limit values; risk assessment

Introduction

Since 1997, several cases of contamination of food and animal feed with polychlorinated dibenzo-p-dioxins (PCDD), polychlorinated dibenzofurans (PCDF), and polychlorinated biphenyls (PCB) have occurred in Europe. As a response to these recent incidents, the European Science Foundation (ESF, in Strasbourg, France) sponsored a meeting of leading scientists from ten countries to discuss these incidents, to evaluate needs arising from them, and to propose steps to better respond to similar incidents and/or to prevent further events of this kind. The ad hoc workshop 'Dioxin Contamination in Food' was held in Bayreuth, Germany, from September 28 to October 1, 2000. This paper summarizes the major findings and recommendations of this workshop.

1 Findings

1.1 Importance of food for human exposure and recent food contamination incidents

Since the early 1990s, food has been identified as the major pathway of human exposure to dioxin-like compounds which are defined here as PCDD, PCDF, and those PCB that possess dioxin-like activity (the non-ortho-substituted and monortho-substituted congeners). Dietary intake contributes about 90-98% of the total daily dioxin intake of the general population. Of this, food of animal origin contributes about 90% of the daily intake in European countries.

The average dioxin intake of Europeans is estimated to be in the range of 0.9 to 3.0 pg/kg b.w./day, assuming an aver-
The control of dioxin sources and exposure is very complex and every effort should be taken for reducing emissions and preventing entry of these contaminants into the food chain. For this, food production practices need to be studied, understood and improved, and there is a need for more traceable and quality assured lines of production and supply inside and outside Europe including movement of food, feed and raw materials across borders. The recycling of waste products into animal feed and human food production chains can cause real problems. Waste management issues will remain a major concern. In particular, the large amounts of PCB, still around in the EU for at least ten years and the request for the disposal/destruction of PCB in installations on EU territory will result in movements of used PCB and PCB-containing wastes. Although legislation is in place, enforcement may not be sufficient at all stages of implementation and additional vigilance is required to ensure that improper handling and disposal does not cause contamination of the environment or the food supply. Given the potential damage from uncontrolled disposal to countries' agriculture and economies, options including, for example, an European Magnum Fund for the free-of-charge disposal/destruction should be considered. In any case, PCB will be an issue for many years to come.

Besides existing legislation, in a pragmatic way, practical measures may be needed, such as not to collect vegetable oil for food use in open parks, etc. or near mineral oil collection, and to inspect, e.g. feed drying facilities to exclude usage of treated wood as fuel.

Dioxin and PCB exposure issues should not be seen in isolation. As an example, the Finnish population is eating more fish, which has contributed to an important improvement in cardiovascular disease prevention although this may seem
Dioxin Contamination in Food

1.2.2 Completion of database on sources and contamination

Dioxin and furan sources are being controlled in Europe although the level of enforcement and the depth of programs vary among countries. The database is still incomplete in Europe although it is better than in any other part of the world. Recent data have shown that non-industrial sources are becoming more significant although they are very difficult to quantify and perhaps to control. There is a lack of data on PCDD/PCDF in products or residues and further measures to control releases are needed. The choline chloride case showed that PCDD/PCDF can enter the food chain through products, in this case wood shavings used in the preparation of this food additive containing PCDD as the wood was treated with PCP (pentachlorophenol).

1.2.3 Regulatory levels

The recent incidents of food and feed contamination have shown that present regulation is not existing or inadequate and a root cause analysis is required to develop appropriate monitoring, prevention and management. Setting feed and food limits alone will not prevent further accidents and there is no way to exclude the possibility of similar incidents to occur in the future unless specific measures are taken. However, regulatory levels would build the legal basis at least to eliminate products with extraordinary contamination levels from the market.

Monitoring of the animal feed production chain could mitigate impacts and identify causes. In contrast to former dioxin cases, which mainly originated from high emissions of individual sources, the recent incidents have been caused by entry of contaminants more directly into the human food chain.

Dealing with these accidents, there are mainly three distinct objectives to address. These require different approaches for assessment, prevention, monitoring and regulatory response:

- Identification and response to an emergency situation of an acute contamination (e.g. Belgian case)
- Identification and seizure of products with exceptionally high levels (e.g. citrus pellet, choline chloride and Brandenburg cases) which can even effect the general population if used to a large extent in the feed and food chain
- Measures aiming to reduce exposure of the general population by ceasing feed ingredients which are higher contaminated than comparable components (e.g. fish meal and fish oil from the Northern hemisphere).

Each case should be carefully addressed and it should be recognized that solutions for one case will not necessarily provide an effective means for the others.

1.2.4 Reacting to scares

Reliable and accurate information is needed and any dioxin contamination – as well as with any other pollutant – has to be put into perspective. Outcries such as the response to findings from Japan that PCDD/PCDF was found in suits, soap, etc., should not happen again. Although many things have been learned, the problem in communication at all levels and inability to get balanced position in the media still exists.

1.3 Human health impact and risk assessment

Human exposure to dioxin-like compounds varies depending on the geographic region. Levels appear to be highest in Inuit populations in Greenland and Northern Canada. In residents from industrialized countries, levels of PCDD, PCDF and PCB are, in general, decreasing.

There are a number of cohorts with high exposure to PCDD/PCDF/PCB, e.g. NIOSH occupational study, veterans of Operation Ranch Hand in Vietnam, residents of Seveso, etc. The NIOSH population of highly exposed (for more than 1 year) and with a 20 year latency period had an increase of all cancers; Ranch Hand population showed increase in diabetes with increasing dioxin levels (no other effects seen); Seveso residents had high levels of dioxin, and although the number of births was relatively few for seven years post exposure, there were highly significantly more girls born than boys (change in normal sex ratio).

From these results obtained in high exposure groups, it seems unlikely that clinically-observable health effects will be found in the general adult population. Therefore, future health studies should concentrate primarily on more susceptible populations, e.g. fetus, infants and young (perhaps senior citizens as well).

The PCDD/PCDF pattern in humans may yield information as to different sources. Also, people from certain geographic regions may have specific patterns because of predominant exposures from different sources, e.g. Europeans have elevated 2,3,4,7,8-C1,DF concentrations compared to U.S. residents.

Health risk assessments consider information from toxicity to exposure. The level of exposure to the general population was previously discussed. However, it is known that certain subpopulations are more exposed than the general population; for example, certain fish-eating populations (such as in Finland and Sweden) and breast-feeding infants.

Current risk assessments (including WHO 1998) are based on long-term, low-level exposures. However, the Belgian incident clearly showed that the general population can be exposed to short-term high-level (peak) exposure. Such in-

---

1 Choline chloride = vitamin B4, an additive for animal feed

2 National Institute of Occupational Health and Safety (USA)
1.4 Analysis

Reliable, reproducible and transparent data are a prerequisite for risk assessment and risk management. Thus, analytical programs and methods must be designed to meet the objectives of the circumstances. The selection of a method for the analysis of dioxin-like compounds must be based on the specific requirements of a given situation, which may differ for

- Emergency situations
- Control of legally binding limit values
- Monitoring to identify those samples that exceed background levels
- Monitoring for intake assessment (daily exposure).

Any method selected must be fit for the purpose and must be validated to ensure that the performance is suitable and acceptable for the task. In this respect, it is mandatory that laboratories successfully participate in proficiency tests for the respective matrices and analytes. Moreover, laboratories performing analyses of dioxins in food and feeding stuffs should have an accreditation in accordance with the ISO 17025 standard or GLP (good laboratory practice) or a combination thereof. For feeding stuffs and food samples, HRMS (high-resolution mass spectrometry) is the current method of choice and the reference method for a precise and reliable determination. As a rule of thumb, the limit of quantification should be 1/5th of the tolerance set by the authorities.

Non-2,3,7,8-substituted PCDD/PCDF congeners can be important for identification of sources, and their determination can provide valuable additional information.

Dioxin-like PCB should be included in the analysis when reporting dioxin results on WHO-TEQ basis. When necessary, all PCB (also the non-dioxin like) should be determined in an analytical program. A clear definition of which compounds are included is required beforehand and must accompany results.

Bioanalytical methods (immunoassays as well as bioassays) are being developed and are becoming more and more available on the market. These methods have potential as screening methods; for instance in monitoring programs to identify specimens of high contamination from background samples. The ones positively tested in the screening test will then have to undergo confirmatory chemical analysis.

Detailed and consistent methods are required to achieve comparable and reliable results. There is a strong need to further validate chemical and bio-analytical methods. Performance requirements and characteristics should be defined to allow an analysis to be made by any method that meets these criteria. Important parameters are:

- Limit of detection (LOD)
- Specificity (ability of a method to distinguish between the analyte being measured and other substances)
- Accuracy (closeness of the mean of repeated analysis to a 'true value')
- Recovery
- Precision (repeatability within a laboratory)
- Percentage of false negatives for a given action level.

Any new methodology, such as bioanalytical methods, or detection principles, should be evaluated by an independent body, i.e. by collaborative studies.

1.5 Limit values

The recent incidents have initiated a lot of discussion about establishing limit values for PCDD/PCDF and perhaps PCB in animal feed and in food for human consumption. Before taking any action in this direction, it should be taken in mind that the main objective of any regulatory measures must be the reduction of dioxin emissions and the control of known sources. Setting limits for feeding stuffs and food can only be a supporting tool and will only be effective in combination with dioxin reduction measures and well-planned monitoring programs.

One appropriate measure to avoid the use of contaminated additives and compounds and to seize products with elevated concentrations from the market seems to set limits for feeding stuffs based on background data. This approach has proven very well for citrus pulp pellets and should be considered also for other products, such as fish meal or fish oil, which were identified as the most heavily contaminated feed materials.

Before setting limit values for food, the objectives have to be clearly defined. For example, measures to significantly reduce human body burden exclusively based on regulatory levels would require much stronger limit values (below...
present background contamination) than measures to seize only highly contaminated specimens from the market. If measures to reduce human body burden will exclusively be based on maximum limits for dioxin-like compounds in food, this would presumably result in a withdrawal of a considerable portion of the human food supply from the market, because it was shown that already the consumption of food with average contamination levels results in a daily intake, that is in the range, or already exceeds, the TDI value proposed by WHO. Obviously, this approach is not reasonable. Therefore, the options recommended by the Scientific Committee on Food (SCF) of the European Commission (Opinion of the SCF on the Risk Assessment of Dioxins and Dioxin-like PCBs in Food, adopted on 22 November 2000; SCF/CS/CNTM/DIOXIN/8/ Final) seems to be more feasible. This approach proposes to set action thresholds and target values for those food groups, which contribute most to the human body burden, linked with measures to reduce emissions and to perform compulsory and well planned monitoring control programs.

Action thresholds could be based on the most recent data on the distribution of contamination levels, collected, e.g. within the European SCOOP project. If action thresholds are exceeded, efforts should be made to identify the source and subsequently prevent or reduce contamination from this source. With respect to the corresponding food item, it should be decided case by case, whether it should be withdrawn from the market.

Target values should be set separately for each food category. These values must be lower than the actual average levels and therefore can only be reached after a further reduction of the emissions into the environment. These values can be estimated on the basis of the share of each food item to the total daily intake based on the actual levels. From this, assuming the same consumption habits, one can deduce the target levels, which are necessary in order to reach the TDI value proposed by WHO. Consequently, target values would be the driving force behind measures necessary for a further reduction of emissions into the environment.

2 Recommendations

Further work is required to build a system of controls and monitoring that will prevent contamination incidents leading to elevated human exposure with PCDD/PCDF and PCB. Practical measures, which ensure that potentially contaminated materials are entirely separated from the food-chain are required. Further, additional work is needed to improve the detection and response to contamination incidents whether they are acute or slightly elevated compared to background.

A major conclusion from the ESF workshop was that food and feed monitoring programs are currently generally inadequate. Programs must be designed to meet carefully defined objectives, to be practical and part of a wider program of controls and measures to ensure food safety and pollution control. It was also recognized that monitoring for compliance with any legal limits set for PCDD/PCDF/PCDF in food could be complex and costly.

The development of practical, effective monitoring and enforcement measures must be an integral part of consideration of any system of food limits. This must take due account of the circumstances of Member States and the most efficient use of limited resources to achieve environmental and public health goals without unjustifiable adverse impacts on other legal and acceptable human activities.

There is a clear need for sustained and long-term activity in this field. There is a real problem with a short-term approach to expertise in this area with bursts of activity followed by a loss of experience and diminution of capability and capacity. Governments and academic programs should be sustained over periods of 10-15 years. Long-term monitoring would be needed over decades. Finally, there is an urgent need to establish consistent and comparable programs to enable data to be compared. Major improvements to ensure transparency of data generation and evaluation are urgently needed.

Analytical standards and procedures should be improved to make results traceable. The establishment of an ESF Network of dioxin laboratories should be considered. There should be at least one laboratory per country within Europe. The goal of such network would be:

- Definition of methods related to specific matrices
- Exchange of samples and interpretation of results
- Cooperative studies involving chemical analysis and bioanalytical methods
- Toxicological aspects (beyond the analytical questions).