PCB IN THE FOOD CHAIN: THE BELGIAN EXPERIENCE AND ELEMENTS FOR A RISK ANALYSIS.

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Introduction

Last year, after various problems in chicken farms and hatcheries, samples of animal fodder were found to be contaminated with dioxins; the source was later identified to be a commercial PCB oil, accidentally mixed into frying fats and thence in fodder. Other known cases of dioxin contamination of animal feedstuffs are: Arkansas (USA), Brazilian Citrus Pulp, German Kaolin.

Arkansas (USA): a dioxin contamination occurred in chickens, eggs and farm-raised catfish. The source of the dioxins was reported to be a contaminated soybean-based feed produced by two companies, both located in Arkansas. The dioxin reportedly appeared when bentonite clay (sometimes called «ball clay») was added to the feed to prevent caking and to improve flow characteristics. The source of the dioxin in the ball clay is unknown and may very well be natural[1].

Citrus pulp: during routine controls in Germany rising levels of dioxin in milk samples were found in 1997. Further analyses revealed that CPP (citrus pulp pellets) originating from Brazil and present in fodder in several European countries contained varying levels of dioxin. CPP is manufactured from orange peels and other orange residues. Lime, some of which a by-product of chemical industry, was used in the process to control pulp acidity[2].

Kaolin: German, Austrian, Swiss and other animal feed was found to be contaminated by dioxins. This was caused by kaolinite charges quarried in Germany. Kaolinite is the main raw material used in the production of porcelain. It is also used in animal feed to improve the flow during pumping when moving the animal feed and possibly as a carrier of low volume additives, such as protein supplements, vitamins, or antibiotics. In June 1999 animal fodder with added kaolinite was found to contain 1.5 to 30 pg I-TE/g resulting in a contamination of German turkeys of 30.6 pg I-TE/g fat. It is not known how the dioxins came into this clay mineral. Possibly even the dioxin pollution was caused in geological times, by processes like forest fires and volcanic eruptions[3].

What happened to Contaminate the Food Chain?

Animal fodder is mainly composed of carbohydrates, proteins and fats, along with some supplements, eg minerals, synthetic proteins, vitamins, etc. Fats and oils, on a weight basis, supply most energy to the animal and are the cheapest components of fodder. They are important in building up tissue. Fats and oils also facilitate the digestion, the absorption of vitamins, and they improve the granular appearance and decrease dusting of fodder. Animal fats are produced in different qualities, e.g. for human food and for animal fodder purposes. The former are derived exclusively from inspected animals and are clean, the latter may also derive from interintestinal fat, the rendering of bones, and from the conversion of animal corpses.

Apparently, in Belgium[4] and the Netherlands[5] 'technical' fats were routinely mixed with animal fats into animal fodder. These technical fats are collected e.g. from the snack-industry, restaurants, large kitchens, ..., melted at a temperature of 90 – 95 °C, and sieved. Most is supplied to chemical industry, as a raw material for producing a variety of products. In the Belgian PCB-case such technical fat was contaminated with commercial PCB oils. Probably the latter were deposited at a public recycling center and mixed inadvertently with other technical fats, then supplied to one or more fodder producers. PCB oils differ in smell from other oils, but can either look alike or darker than vegetal oil. So it is possible that PCB oils were added to other technical fats. The fodder industry controls the fats on various parameters, e.g. water and free fatty acids, to verify if the fats are still of good quality and did not become rancid or polymerized by oxidation. The principal victim in that industry is ISO-certified and played an important role in tracing the original pollution. It was much more difficult to trace the origins and further movements of the technical fats at the origin of the trouble.

The first symptoms observed was a decline in laying eggs and a decrease of hatchability and chickbirth. Chicks were also affected by the following diseases: Oedema, Ascites, and Ataxia. The chicken affected where slaughtered and – as the chemical nature of their disease was not yet known - used for mingle in fodder, which caused a second contamination. Other chicken, that were apparently unaffected were probably consumed but up-to-date not a single case of human poisoning has been declared.

It was a long way to discover the source of the problem, because the symptoms of the chicken were not immediately recognized and the potential causes were trailed methodically, but only sequentially: a new supply of proteins, the potential presence of heavy metals, and ultimately, dioxins. The fingerprint of the latter was not recognized immediately to be 'chemical' in origin.

When Belgian Authorities found out that animal fodder was contaminated with dioxins, they first located the time period when the contamination occurred and the enterprises that possibly received contaminated fodder, then took measures to avoid that the contamination would spread further. All suspected farms or breeders were blocked and their products taken out of the trade. Huge numbers of potentially suspect samples had thus to be analyzed for their PCB content, in order to allow them to be distributed, or not. Thus a problem of PCB analytical capacity was created.

Methods and Materials

Because of PCB contamination, Belgian authorities decided to analyse only for the seven marker PCB congeners in order to detect contamination in the samples and only to perform a PCDD/F analysis if a serious PCB concentration was found. The seven marker congeners used are PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 and PCB180; all are easy to analyse. A PCB analysis is much faster and cheaper then PCDD/F analysis. Analyses were performed by different laboratories and each used its own analytical method, that first had to be validated by Belgian authorities. A technical assessment was carried out in order to evaluate if the laboratories had enough skilled personnel and adequate equipment.

Results and Discussion

To evaluate the results of the samples analysed, these are subdivided by their origin: contaminated fat, foodstuff, chicken, eggs, and pig samples, and also by the laboratory that analysed them. The samples of the same origin and analysed by the same laboratory could be compared to verify whether there was a single or a multiple source of contamination, and then can be made into a profile, presenting the weight percentage of the seven marker PCB congeners in a graph, called PCB profile. When samples of the same origin, but analysed by a

different laboratory are compared, there is often a marked difference in both concentration and profile. However, this was no problem when the main task was to separate the clean from the contaminated samples. It was more of a problem when ascertaining that there was a single and not a multiple source of pollution.
In the following figures some PCB-profiles are shown, with an average wt.% distribution for fat, fodder, chicken and egg samples, as analysed by different laboratories.

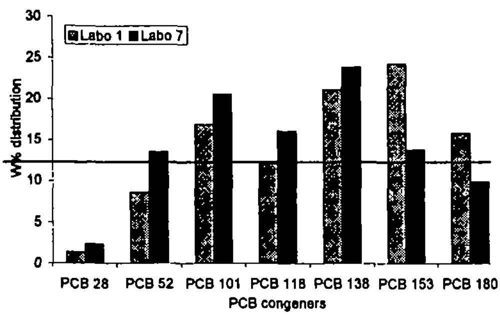

Figure 1: PCB-profile of fat samples

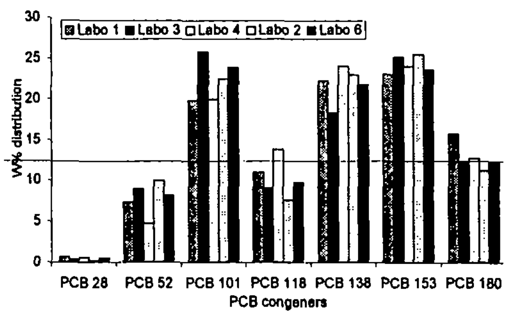

Figure 2: PCB-profile of fodder samples

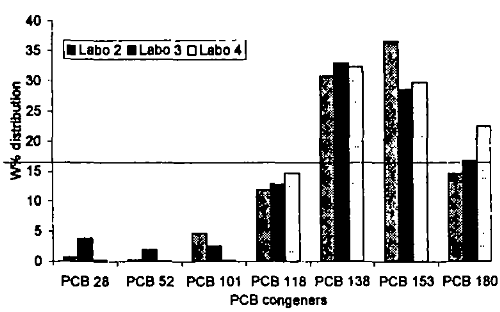

Figure 3: PCB-profile for chicken samples

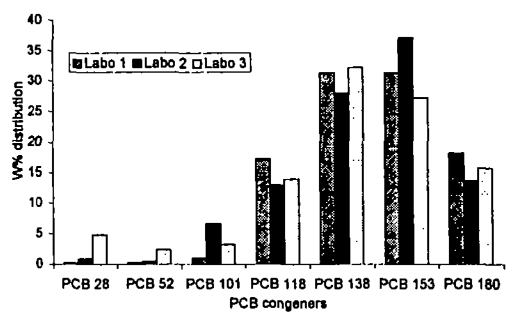

Figure 4: PCB-profile for egg samples

A marked difference is apparent between the PCB-profiles of e.g. chicken samples and the original fodder or fat samples. The difference is due to distinct, but poorly documented selectivity factors in animal metabolism and excretion. An estimation can be made of the potential exposure of consumers to the PCB-contamination and the result can be compared to the TDI-value (Total Daily Intake) of 1 – 4 pg TEQ/kg bw/day as given by the WHO. Acute exposure:

Consumption of_chicken = 300 – 350 gram meat
Fat-content 15 – 20 % ⇒ 45 – 70 gram fat
Contamination = 1.000 – 2.600 pg I-TEQ/g fat
⇒ 45.000 – 182.000 pg I-TEQ
Body weight of a person = 70 kg
⇒ 640 – 2.600 pg I-TEQ/kg bw
Compared to the TDI = 160 – 2.600 times higher
50 % absorbed of additional load
⇒ 0.32 – 1.3 ng I-TEQ/kg bw/chicken consumption

Longterm assimilation:

Yearly average consumption of 1 gram contaminated chicken fat
Contamination = 1.000 – 2.600 pg I-TEQ/g fat
$\Rightarrow$ 1.000 – 2.600 pg I-TEQ
Body weight of a person = 70 kg
$\Rightarrow$ 14 – 37 pg I-TEQ/kg bw
Compared to TDI = 3 – 37 times higher

Lessons to be learned

In Belgium the dioxin chicken was considered big scandal. Moreover, it was a big problem to the Belgian food sector, used to export throughout the E.U. and sometimes overseas. A number of lessons can be learned, regarding int.al.:

- the necessity of adequate controls in recycling materials in the animal fodder chain, or even elsewhere (in Vietnam food poisoning occurred by the use of lead contaminated aluminium cooking pots),
- the logistic chains should be adequately documented,
- adequate analytical facilities may be lacking, in a case of massive food poisoning.

Conclusions

The Belgian dioxin crisis probably could have happened anywhere, due to limited controls over all entries in the animal fodder chain and hence the potential that undesirable substances enter the food chain. The economic damage was enormous, although – fortunately – not a single human victim of poisoning has been identified. The dioxin crisis exposed a number of potential weaknesses at a large variety of levels, with an emphasis on missing data and knowledge limitations encountered in this crisis.

Acknowledgements

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