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Directorate C - Scientific Opinions
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OPINION OF THE

SCIENTIFIC COMMITTEE ON ANIMAL NUTRITION

ON THE

DIOXIN CONTAMINATION OF FEEDINGSTUFFS AND THEIR CONTRIBUTION TO THE CONTAMINATION OF FOOD OF ANIMAL ORIGIN

ADOPTED ON 06 NOVEMBER 2000

Background

The health significance of human exposure to PCBs and dioxins has been subject of extensive discussions. The most recent assessment of the risks for human health from PCBs and dioxins has been performed in 1998[1], when a WHO consultation group agreed on a tolerable daily intake (TDI) of PCDDs/PCDFs (“dioxins”) and dioxin-like PCBs in the range of 1 – 4 pg Toxic Equivalents (TEQ)/kg body weight, stressing that the upper range of the TDI of 4 pg TEQ/kg should be considered as a maximum tolerable intake on a provisional basis and that the ultimate goal is to reduce human intake levels below 1 pg TEQ/kg bw/day.

There are clear indications that the major source of human background exposure is food[2] (more than 90 %) with food of animal origin being the predominant source. The Scientific Committee on Food (SCF) was asked recently to advise the Commission on the scientific elements necessary for the establishment of limits and/or alternative measures aiming at reducing the dietary intake of PCBs and dioxins. The recent cases of contamination of feedingstuffs (citrus pulp pellets, oils and fats and kaolinitic clay) highlighted the impact of contaminated feedingstuffs as a source of contamination of food of animal origin with dioxins or PCBs.

In order to complement the SCF evaluation of risks related to human dietary exposure, the Commission requests an evaluation of the contribution of feedingstuffs contaminated with dioxins, PCBs and dioxin-like PCBs to the contamination of food of animal origin.

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1 VAN LEEUWEN, F.X.R., and YOUNES, M.M. Consultation on assessment of the health risk of dioxins: re-evaluation of the tolerable daily intake (TDI): Executive summary. Food Additives and Contaminants, Vol. 17, no. 4 (April 2000). pp. 223 - 240.

2 FÜRST, P, BECK, H., and THEELEN, R.M.C. (1992)
Assessment of human intake of PCDDs and PCDFs from different environmental sources. *Toxic Substances Journal*, **12**, 133-150.

Terms of reference

Considering the above, the Scientific Committee on Animal Nutrition is requested:

(1) to identify feed materials which could be considered as sources of contamination of feedingstuffs by dioxins, PCBs and dioxin-like PCBs, and to characterise as far as possible the distribution of levels of contamination in each of them (*e.g.* average, upper levels)

(2) to assess the contribution of the different identified feed materials as sources of contamination to the contamination of food of animal origin, taking into account both the dietary variations in relation to animal categories, including fish, and the carry-over rate of dioxins and PCBs (matrix and congener dependent) in the different products of animal origin.

(3) insofar relevant, to evaluate the impact on animal health of the presence of dioxins and PCBs in the feedingstuffs and at the levels identified under (1)

(4) to identify the eventual gaps in the available data which need to be filled in order to allow a complete evaluation.

In view of the fact that the above mentioned WHO consultation group recommended the inclusion of the dioxin-like PCBs in the calculation of TEQs, the Committee is asked to distinguish between dioxins (PCDDs/PCDFs), PCBs and dioxin-like PCBs as far as the available data allow, in making its evaluation.

Time limit

In view of a possible legislative action in this area, the Committee is asked to complete its evaluation as soon as possible.

Executive summary

The SCAN has been asked to advise the Commission on the sources of contamination of feedingstuffs by polychlorinated dibenzo-*p*-dioxins and dibenzofurans, collectively known as dioxins, and by polychlorinated biphenyls (PCBs), including dioxin-like PCBs. Advice was also sought on the likely exposure of food producing animals (mammals, birds and fish) to dioxins and PCBs, on the carry-over of these compounds to food products of animal origin and on any impact of dioxins and PCBs present in feedingstuffs on animal health.

In reaching its conclusions, the SCAN has taken into consideration all of the available published data and additional information obtained by the European Commission from Member States and other sources. Account has been taken of the environmental sources of pollution resulting in the background contamination of all feed materials and also of any contamination specifically introduced by production conditions, feed processing and during the transport and distribution of feed materials and feedingstuffs. Because of the scarcity of reliable data on PCBs, these are not included in this analysis.

As a first task, SCAN prepared a list of typical diets for the main animal species and categories representative of those in common use within the European Union. Where possible, values for upper, lower and mean concentrations of dioxins for each feed material were taken from the available data. In practice, because of the scarcity of data and difficulty of analysis, some feed materials had to be grouped. The upper values used do not necessarily represent the highest percentile of the total data, but were more arbitrarily chosen to represent worst-case situations. For example, forages grown in proximity to a source of pollution can have upper values substantially higher than those of forages grown elsewhere. Particular attention was paid to soil as a source of dioxin contamination. Soil is deposited onto the aerial surfaces of all plants and is consumed by free-ranging animals before harvest and, in lesser amounts, by other animals post-harvest.

The total dioxin concentration for each diet was then calculated using the low, mean and high values for the dioxin content identified for each ingredient or group of ingredients to identify the main sources of contamination.

The main SCAN conclusions are:

- Fish meal and fish oil are the most heavily contaminated feed materials with products of European fish stocks (respective means (for dioxins only) of 1.2 and 4.8ng WHO-TEQ/kg DM) more heavily contaminated than those from South Pacific stock (Chile, Peru, respective means (for dioxins only) 0.14 and 0.61ng WHO-TEQ/kg DM) by a factor of *ca* eight.
- Animal fat (mean 1ng WHO-TEQ/kg DM) is next in order of dioxins concentration. Values observed depend on the bioaccumulation of dioxins in fatty tissues along the feed/food chain.
- All other feed materials of plant (roughages, cereals, legume seeds) and animal (milk by-products, meat and bone meal) origin contain mean concentrations of dioxins around or below 0.2ng WHO-TEQ/kg DM.
- Roughages present a very wide range of dioxin concentrations depending on location, degree of contamination with soil and exposure to sources of aerial pollution, justifying the use of a worst-case assumption in identifying relatively high mean and upper values.

- The limited data available on the contamination of feed materials by dioxin-like PCBs indicates that their inclusion would increase the TEQ value for feed materials of fish origin by a factor of five and that of other feed materials by a factor of two.
- The contribution of individual feed materials to the dioxin content of the whole diet for farmed animals depends on the intrinsic degree of contamination and the proportion used in the diet. Greatest concerns arise from the use of fish meal and fish oil of European origin. These are most critical when used in diets for farmed fish and where fish meal is incorporated in diets of other food producing animals.
- The consumption of contaminated soil may drastically increase the exposure of grazing or free-ranging animals to dioxin. However, the bioavailability of dioxins adsorbed on mineral or organic soil particles is limited.
- The SCAN stresses that depending on the degree and position of chlorination, the individual dioxins (congeners) exhibit different transfer rates, and that it is not scientifically correct to calculate transfer from feedingstuffs to products of animal origin on a TEQ basis only. The exercise must consider the individual congeners.
- With regard to the impact of dioxins on animal health, the SCAN considers that no adverse effects from dioxins would be expected in mammals, birds and fishes exposed to the current levels of background pollution. Toxic consequences would be expected in animals challenged by severe accidental contamination with dioxins or PCBs.

SCAN recommendations:

The reduction of human exposure to dioxins related to food consumption is important to ensure consumer protection. Food of animal origin is a predominant source of exposure of consumers to dioxins. As food contamination is directly related to feed contamination, consistent cross-sectorial actions must be taken to reduce final dioxin impact on human health.

An integrated approach should be followed to reduce the dioxin incidence all along the food chain *i.e.* from feed materials to food producing animals then to humans. Taking measures on feed materials and feedingstuffs is thus an important step to reduce the dioxin uptake by human.

As far as feed materials are concerned,

- Emphasis should be put on reducing the impact of the most contaminated feed materials, *e.g.* fish meal and fish oil from Europe, on overall diet contamination. This could be achieved by substituting the most contaminated by lesser contaminated sources, by reducing their intrinsic contamination or by using non (less) contaminated alternatives, continuing to meet the animal nutrient requirements.
- Any material (recycled products, raw materials, ingredients) used in the manufacturing of feed materials should be guaranteed for quality and safety so that it would not become a source of contamination.
- Good manufacturing practices as well as use of Hazard Analysis and Critical Control Point principles should be introduced/continued at feed industry level to control the dioxin contamination along the different steps of the manufacture of feed.
- Efforts should be made to reduce dioxins contamination of feed resources at farm level (Good agricultural practices) and controlling local conditions of livestock

production (*e.g.* direct environment of dairy farms, free range animal production), in particular in areas where soil contamination is elevated.

In addition, considering the impact of the environmental pollution on the contamination of feed materials, measures implemented with the aim to reduce the general dioxin burden should be actively continued.

There is a need for data on dioxins, but also dioxin-like PCBs and PCBs contamination of the widest range of feed materials and feedingstuffs in order to determine background levels so as to identify unknown contamination sources. A particular effort should be put into obtaining more data for feed materials for which a wide range of contamination is reported.

Scientific cooperation should be promoted in order to collect and collate information available in the different Member States at the EU level.

Monitoring programs could be organised at European level in order to widen the current limited geographical basis of the information on feed materials contamination.

Regarding the huge amounts of feedingstuffs being produced and sold world wide, feed materials imported from third countries should be checked for their dioxin content with the aim to avoid additional dioxin burden on feedingstuffs.

Data should be obtained from fully identified samples (contaminated or not) and techniques. In particular, two important aspects: indications or checks, whether samples were possibly contaminated, and the definition of the limit of determination have to be considered and reported to make data useful and useable. The concept of upper bound determination limits should therefore be implemented.

Analytical means should be developed and appropriate analytical requirements adopted according to the aim of the analysis carried out. For instance, in the case of checks of dioxins levels for control purposes, the analytical limits of determination should be in the range of one fifth of the regulatory limits whereas for control of time trends of background contamination, the limit of determination should be clearly below the mean of the present background ranges for the different matrices.

Emphasis should be put also on quality and qualifications of laboratories involved in monitoring programs and control activities of or for feed producers. Interlaboratory calibration studies should be promoted, using reference materials with certified dioxin and dioxin-like PCBs contents which should be made available. With this regard, the Committee welcomes the recent initiative of the European Commission (2000/C 290/05)[3] inviting for submission of proposals to support the development of Certified Reference Materials, in particular in the field of environmental contaminants in food and animal feed (topic IV.20) and specifically for PCDDs, PCDFs and PCBs in food and feed products. Such actions should be promoted.

Basic research is needed on studying the carry-over and establishing pertinent transfer factors for dioxin-like PCBs congeners from soil and feed to animals tissues and products (milk, eggs).

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3 OJ n° C 290 of 13.10.2000, p. 4

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Acknowledgement

SCAN adopted this opinion on the basis of the preparatory work done by the SCAN ad'hoc Working Group, which included members of the Committee and the following external experts:

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1. INTRODUCTION

1.1. Dioxins (polychlorinated dibenzo-p-dioxins and dibenzofurans)

Polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) belong to the group of lipophilic and persistent organic contaminants. PCDDs and PCDFs are often referred to simply as “dioxins”. Depending on the degree of chlorination (1 - 8 chlorine atoms) and the substitution pattern, one can distinguish between 75 PCDDs and 135 PCDFs, called "congeners". Although dioxins do not have any benefits and therefore, with the exception of research and analytical purposes, were not produced specifically, these contaminants have meanwhile found an ubiquitous distribution due to their formation as unwanted and often unavoidable by-products in a number of industrial and thermal processes.

The toxicity of dioxins differs considerably. In particular, those congeners, which are substituted in the 2,3,7,8-position, are of special importance. Thus, of the 210 theoretically possible congeners, only 17 are of toxicological concern. These compounds show a similar toxicity to that of the most toxic congener 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), also known as "Seveso-dioxin".

In order to facilitate the comparison of analytical and exposure data, it has proven useful in the past to convert the analytical results of the determination of all 17 congeners of toxicological concern into one summarising result which is expressed as toxic equivalents (TEQ). This conversion is based on the assumption that all dioxin congeners show similar qualitative effects (binding to the same dioxin-receptor) but with different intensities. The different binding activity is expressed by toxic equivalency factors (TEF), estimated from the weaker toxicity of the respective congener in relation to the most toxic compound 2,3,7,8-TCDD, which is assigned the arbitrary TEF of 1. Moreover, it is assumed, that the effects are nor synergistic or antagonistic, but additive. By multiplying the amount of each congener present with the corresponding TEF, the TEQ value of a sample is generated. Different TEF models have been developed in the past. On the international level, the TEF values proposed in 1988 by a NATO/CCMS working group and the 1997 revised TEFs proposed by a WHO expert group are the most widely used (Van den Berg *et al*., 1998). The resulting total toxic equivalents are expressed as I-TEQ (NATO/CCMS) or WHO-TEQ (WHO).

1.2. Polychlorinated biphenyls

Polychlorinated biphenyls (PCBs) belong to the group of chlorinated hydrocarbons, which are synthesised by direct chlorination of biphenyl. Depending on the number of chlorine atoms (1-10) and their position at the two rings, there are 209 different compounds, called “congeners”, theoretically possible.

In contrast to dioxins, PCBs were produced for technical use. The technical products were liquids with different viscosity depending on the degree of chlorination (between 42 and 60 % chlorine) and mixtures with dozens of congeners. Due to their physical and chemical properties, such as non-flammability, chemical stability, high boiling point, low heat conductivity and high dielectric constants, technical PCB mixtures were widely used in a number of industrial and commercial open and contained applications. Contained applications include the use of PCBs in hydraulic and heat transfer systems as well as cooling and insulating fluids in transformers and capacitors. The use of PCBs in pigments, dyes, repellents and carbonless copy paper or as plasticizers in paints, sealings, plastics and rubber products are typical examples of open applications. It is estimated that more than 1 million tons of technical PCB mixtures have been produced world-wide since their first commercial use in the late 20s.

Concern over their persistence in the environment and their toxicity has led to strict regulations within the European Union and other countries of the Western World in the past two decades. Although the manufacture, processing and distribution of PCBs has been prohibited in almost all industrial countries since the late 80s, their entry into the environment can not be excluded, especially due to improper disposal practices or leaks in transformers and hydraulic systems. In this respect, it should also be noted that, in accordance with Council Directive 96/59/EC of 16 September 1996 on the disposal of polychlorinated biphenyls and polychlorinated terphenyls (PCB/PCT)[4], the deadline for the decontamination and/or disposal of equipments and the PCBs contained therein shall be effected at the latest by the end of 2010.

Technical PCB mixtures always contain a certain amount of polychlorinated dibenzo-p-dioxins and dibenzofurans, formed as unwanted by-products during synthesis. This amount can be increased significantly when PCBs are involved in fires or are heated in the presence of oxygen at temperatures below 1000°C.

From a toxicological point of view, PCBs can be divided into three groups. While non-ortho and mono-ortho substituted PCBs show higher toxicological properties that are similar to dioxins, and therefore are often termed "dioxin-like PCBs", the di-ortho substituted PCBs are less toxic and have different toxicological properties. Based on the available toxicological information, the non-ortho PCB congeners 77, 81, 126 and 169 and the mono-ortho PCB congeners 105, 114, 118, 123, 156, 157, 167 and 189 were assigned a toxic equivalency factor (TEF) by a WHO expert group in 1997 (van den Berg *et al.*, 1998). The mono-ortho PCB 28 and the di-ortho PCBs 52, 101, 138, 153 and 180 (as well as sometimes also the mono-ortho PCB 118) are called "marker PCBs" and are the decisive congeners in regulations of tolerances for PCBs in all kind of matrices so far.

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4 OJ n° L 243 of 24.09.1996, p. 0031 - 0035

1.3. Polybrominated dioxins and furans

In addition to the chlorinated compounds, brominated dioxins (PBDDs) and furans (PBDFs) are of toxicological concern. The Federal Health Office (Bundesgesundheitsamt) in Germany concluded from the available data that in principle the same toxicological effects were induced. Therefore, it recommended the application of the same TEFs as used for the chlorinated compounds (Appel, 1989, Appel, 1992). If brominated and chlorinated compounds are present simultaneously, the sum of both should be considered for the recommended tolerable daily intake. However, much less data are available for a final conclusion.

The available data indicate that the levels of PBDDs/PBDFs in the food chain are much lower than of PCDDs/PCDFs. Thus, these compounds were not considered during the WHO re-evaluation of TEFs in 1997, during the development of the new TDI recommendation of WHO in 1998 or in the compilation of EU dioxin exposure and health data in 1999.

PBDDs/PBDFs can derive from the use of flame retardants for fire protection, such as polybrominated diphenylethers, bromophenols (tetrabromobisphenol A) or polybrominated biphenyls. Laboratory studies have shown that certain flame retardants and ignition-proof plastics can release under thermal exposure large amounts of PBDDs and particularly PBDFs.

There are no indications that significant amounts of PBDDs/PBDFs have entered the food chain. However, accidents with fires involving brominated flame retardants could have had a local effect. It is not clear whether brominated compounds have the same stability (*e.g.* against UV radiation). There is concern that the global use of brominated flame retardants could lead to increasing levels of PBDDs/PBDFs in the future.

1.4. Tolerable daily intake of dioxins and PCBs

At certain levels of exposure and body burden, dioxins and dioxin-like PCBs can lead to severe perturbations of immune and endocrine functions and reproduction as well as to the development of malignant tumours. Based on new data on adverse effects of 2,3,7,8-TCDD on reproduction and neurobehaviour in rodents and monkeys, together with novel information on the molecular and cellular mechanisms of dioxin toxicity, the World Health Organisation (WHO) revised in 1998 its recommendation from 1990 and proposed a new tolerable daily intake value (TDI) for humans of 1-4 pg WHO-TEQ/kg body weight (Van Leeuwen and Younes (2000)). The consultation stressed that the upper range of the TDI of 4 pg TEQ/kg bw should be considered a maximal tolerable intake on a provisional basis and that the ultimate goal is to reduce human intake levels below 1 pg TEQ/kg bw/day. Besides dioxins, this TDI value includes also the above mentioned 12 polychlorinated biphenyls (PCB) which show dioxin-like effects.

In the past, most of the toxicological experiments were not performed with individual congeners, but with technical PCB mixtures. For this reason, it is often very difficult to attribute observed toxicological properties to individual PCBs or to PCBs as a whole, because it can not always be excluded that these effects were in fact overlaid for example by dioxins being present as contaminants. Nevertheless, these experiments provided the basis for the estimation of a tolerable daily intake (TDI) value which was proposed by OECD in 1988 and adopted in many countries as 1 µg total PCB/kg body weight. This TDI is about 6 orders of magnitude higher than that for dioxins.

1.5. Human Exposure

Humans are exposed to dioxins and PCBs through either

- occupational exposure,
- accidental exposure or
- environmental (background) exposure.

In the past few years a number of studies have been performed in order to estimate the human dioxin exposure and the contribution of the different routes to the body burden of these compounds. While specimens from humans exposed to background contamination show a similar congener pattern, those from individuals occupationally or accidentally exposed are dominated mostly by the PCDDs/PCDFs congeners which are characteristic of the respective sources of contamination

Human dioxin exposure through background contamination is possible by several routes:

- inhalation of air and ingestion of particles from air,
- ingestion of contaminated soil,
- dermal absorption,
- food consumption.

The first three routes normally contribute less than 10% to the total daily dioxin intake, while more than 90% of human dioxin exposure derives from food. About 90% of the latter come from food of animal origin. As is seen for humans, the dioxin body burden of animals (and therefore the contamination of food products of animal origin) originates mainly from feed contamination. Therefore feedingstuffs are of special concern in the carry over of dioxin contamination to the human food chain.

Feed, food producing animals and finally food products of animal origin may become contaminated with dioxins through *e.g.*:

- deposition of emissions from various sources on farmland,
- burning of raw material containing potential dioxin sources for direct drying,
- blending of feedingstuffs with dioxin containing products and/or raw materials,
- application of contaminated pesticides, detergents, disinfectants etc.,
- contact with / consumption of wooden materials treated with wood preservatives,
- application of sewage sludge on fields,

– flooding of pastures,
– contamination of water with waste water and effluents,
– food processing
– migration from chlorine bleached packaging material.

Due to the lipophilic properties of dioxins and their well-known accumulation in the food chain, food samples of animal origin are of special importance for a risk assessment of human exposure. While normally specimens of plant origin normally only contain levels near the detection limit, all samples of animal origin show typical patterns of PCDDs and PCDFs. Predominant congeners are those with 2,3,7,8-chlorine substitution belonging to the toxic dioxin compounds.

At the end of the 80s, for reasons of safety, various countries took measures to reduce the dioxin emissions and to lower their levels in the environment, because at that time it was estimated that the daily dioxin intake exceeded the TDI value proposed by several health authorities. The success of these measures is demonstrated by a significant reduction of the dioxin contamination of the environment and particularly of food in many countries. For Germany, The Netherlands, and the United Kingdom, data are available for a number of years, allowing time trend analysis (European Commission, 1999a). In The Netherlands a constant decrease of 50% of the intake of I-TEQ/kg bw/day over each interval of 5.5 years over the period 1978 to 1994 was observed. In the United Kingdom, three data points are currently available, for 1982, 1988 and 1992, that show the exposure has also fallen from 4 pg I-TEQ/kg bw/day in 1982 to 2.1 in 1988 (48% decrease) and 1.15 in 1992 (another 45% decrease). Recent investigations of German food samples have shown dioxin levels approximately 50% lower than corresponding samples collected and analysed 10 years ago. As a result, the average daily dioxin intake for adults was reduced in the meantime from around 2 pg TEQ/kg body weight to below 1 pg TEQ/kg body weight. However these very consistent results show that even in those countries which took measures to minimise dioxin emissions, the average daily dioxin intake is in the range of, or still exceeds, the TDI value proposed by WHO in 1998. If dioxin-like PCBs are also considered, the resulting intake is approximately doubled and the present picture worsened.

Where monitoring programmes are available, important reductions in the dioxin content of human blood and mothers' milk could be observed in the past ten years. However, data from Germany and Spain indicate that this reduction seems to be levelling out at the end of the 90s. The successful reduction of the dioxin content in man at the beginning of the 90s is the result of measures to reduce emissions from various environmental sources. At the end of the 90s, however, more focus has been put on the possible contribution of feedingstuffs to exposure of human beings to dioxins, as a consequence of a more intensive monitoring, which followed some episodes of critical contamination of feedingstuffs by dioxins.

Comparable data on PCBs are still scarce and often are difficult to compare because the selection of PCBs determined in the different studies varies considerably. Limited data available from industrialised European countries indicate that the average daily total PCB intake for humans through background exposure is approximately one tenth of the proposed TDI value. The assessment of dietary intake of dioxins and dioxin like PCBs by the population of EU Member States (SCOOP task 3.2.5, June 2000) revealed large differences in the amount, detail and quality of the data from the participating countries. Therefore, the participants of the SCOOP task recommended that the collection of occurrence and food consumption data should be repeated every 5 to 10 years because it was considered extremely valuable to compare and follow temporal trends in the exposure of the populations of different European countries to dioxins and related compounds.

2. DIOXIN SOURCES OF FEEDINGSTUFFS CONTAMINATION

2.1. Major cases of dioxin contamination of feed since 1997

The finding of a high dioxin contamination in feed material for fish and poultry in the USA in 1997, in citrus pulp pellets (CPP) from Brazil in 1998 or in fat from Belgium 1999 raised the question whether certain feedingstuffs bear a higher risk of a possible dioxin contamination. Thus, the major "accidents" are described and discussed in more detail:

(1) In 1997, the FDA identified the source that caused elevated levels of dioxin in two poultry samples as that of a clay material called "ball clay" used as anti-caking agent. Feed manufacturers and commercial catfish and egg producers were warned not to ship products that may be contaminated. This was the first finding of a dioxin contamination of this type of technological additive. For a long time, the reason of the contamination remained unclear. In 1999, a similar contamination occurred in Europe in kaolinitic clay which was used as "anticaking agent" as well, and for production of mineral feed. Gradually it became obvious that a natural source was involved. Possibly, geothermal processes formed this unique pattern of dioxins over time from organic material and chlorine. Data presented at the dioxin congress in Venice in September 1999 showed that this unique dioxin pattern could be found in different regions in the world: in the Mississippi basin (where the ball clay was mined), in the Westerwald area in Germany (where the kaolinitic clay was mined) and in sediments at the East coast of Australia.

(2) In 1998, citrus pulp pellets (CPP) from Brazil with high dioxin contamination were found (Malisch, 2000). Comprehensive investigations revealed that the use of highly contaminated lime (calcium hydroxide) was the source of the dioxin contamination of this CPP. Lime is added to wet peels, seeds and pulps of oranges in order to facilitate the drying process and to raise the pH from between 2 and 3 up to between 6 and 7. Lime constitutes about 2 % of the dried CPP. In the past, the CPP producing industry in Brazil purchased quicklime or hydrated lime either from suppliers of mined "virgin" lime or from lime converters. The highly contaminated lime used for CPP production came from one supplier. It turned out that this supplier was a converter. This lime converter purchased, at that

time, one of the main ingredients, lime milk, from a specific lime milk supplier who generated the lime milk as a by-product from a production process. Thus, citrus pulp as such should not be considered as a dioxin risk but the use of chemical by-products or waste for manufacturing of feed materials, which may lead to their contamination.

(3) In 1999, in Belgium the contamination of fat used for production of feedingstuffs caused a severe contamination of different animal products. Finally it turned out that the discharge of a technical PCB mixture at fat collection sites used for feedingstuffs production had caused this massive dioxin contamination. Used PCB products are well known for their high dioxin contamination and have to be discharged as hazardous waste.

(4) In 1999, grass meal with high dioxin contamination was found in the German state Brandenburg. Here, the dioxin contamination came from the drying process in which all types of wood were burnt, including waste wood with chemical contamination from paints or preservatives.

(5) In June 2000, dioxin levels were found in certain premixtures containing choline chloride originating from Spain. Classified as a provitamin, choline chloride is used as an animal feed additive. Investigations tracing back the source of contamination revealed that the pure choline chloride was not the source of the problem but the carrier of plant origin was contaminated. Although declared as corn cob meal, the carrier also included rice husks and/or saw dust presumably treated with a wood preservative. The congener pattern found in the contaminated lots matched those typical of pentachlorophenol contamination, which is used as a wood preservative.

All the above cases demonstrate that contamination of feedingstuffs by dioxins and PCBs may occur at different levels of the feed chain and have very different origins:

- Additives from either natural or synthetic origin used in feed processing as a possible dioxin source (*e.g.* kaolin and lime)
- Technological processes applied to feed, directly generating contamination (*e.g.* drying process)

As a result, the inventory of dioxin sources which was used to reduce the dioxin emissions into the environment should also be extended to the domain of feed materials and feedingstuffs production.

2.2. Environmental contamination of feed materials by dioxins

The contamination of the environment by dioxins is primarily caused by the aerial distribution and deposition of emissions from various sources (waste incineration, production of chemicals, traffic, etc.). Moreover, application/disposal of chemicals could contribute to more severe and localised contamination of the environment in general and of feed materials in particular.

Soil is a natural sink for this kind of persistent and lipophilic compounds. Adsorption to the organic carbon fraction of the soil takes place, and once adsorbed the dioxins remain relatively immobile. Soil is a typical accumulating matrix with a long memory, which reflects the base line contamination of a region. Apart from atmospheric deposition, soils may be polluted by the application of sewage sludge or composts, and by spills and erosion from nearby contaminated areas. The intake of soil by free-range grazing (ruminants, birds) or grazing/burrowing animals (pig, wild boar) is different to a large extent, and take place directly or through dust deposits on vegetables.

As soil to plant transfer of dioxins is very limited (see in the following chapters), aerial distribution and deposition of dioxins and dioxin-like PCBs are the main sources of contamination of leafy vegetables. Further distribution in the plant is limited and restricts contamination of seeds and of most plant by-products. Leaves are either directly grazed by free-ranging animals, or cropped and then preserved under dried form (hay) or silage. Spreading of sewage sludge, adhering on the vegetation, increases to a limited extent the exposure of livestock (European Commission, 1999a).

Dioxins and dioxin-like PCBs are poorly soluble in water. However they are adsorbed onto mineral or organic particles in suspension in water. The surface of oceans and seas is exposed to aerial distribution of these compounds and consequently they are concentrated along the aquatic food chain. Fishes (products) used as feed materials are therefore of particular concern. This is especially true for those areas where in addition waste waters or contaminated effluents from certain processes, such as paper pulp bleaching, are introduced into the aquatic system. Terrestrial free range domestic animals and semi-wild animals drinking river or pond water can be exposed also to a limited extent.

2.3. Biogenic origin of dioxins in minerals

The finding of uncommon but similar PCDDs and almost PCDF-free profiles in different types of clays protected from the present anthropogenic contamination, strongly suggests a natural origin for these compounds (Jobst H., 2000). Comparable patterns for the most abundant hexa-, hepta- and octa-CDDs were found in sewage sludge both from 1933 and 1981/82, despite the fact that production of pentachlorophenol (PCP) did not commence until 1938. This suggests that a natural chlorination process is involved (Lamparski *et al*., 1984). More recently, it has been shown experimentally (Oberg *et al*., 1992; Rappe *et al*., 1999) that normal sewage sludge fortified with isotopically labelled PCP generates after a few weeks hepta- and octa-CDDs (but not penta- and tetra-CDDs) through a dimerization reaction. Important natural sources of PCP such as composting have been reported (Sievers *et al*., 1994; Oberg *et al*., 1994). Therefore, depending on the very specific local conditions required for the bioproduction of PCP (or other simple organic chlorine compounds) and subsequent chemical or biochemical dimerization processes that prevailed when the sediments were formed, the deposits exploited today may be either low or highly contaminated with these specific PCDDs.

2.4. Identification of hazards along the production and processing of feed materials and feedingstuffs

2.4.1. Production of feed materials

Many by-products of food processing (*e.g.* starch, sugar, oils and fats, fruit and vegetables transformations) and biotechnology (*e.g.* biosynthesis of organic acids and amino-acids) are used as feed materials. The dioxin and dioxin-like PCBs burden of the usual feed materials of plant origin used as raw material is examined further on in the opinion. However, special attention should be given to a possible contamination, which may occur at certain steps of the production process of these by-products, namely when chemical substances like catalysts, solvents, pelleting aids, pH modifiers or filtration agents are introduced. This is illustrated by the example of the dioxin contamination of citrus pulp.

2.4.2. Processing of feeds materials and feedingstuffs

Feed materials and feedingstuffs undergo usually one or more processing steps.

a) Mechanical steps

Grinding, mixing, pelleting and extrusion are basic operations in the preparation of feedingstuffs. These mechanical operations involve friction shear of different intensities which, even for the most severe (extrusion), may increase the temperature to a maximum of about 230°C. Addition of steam is frequently used which does not increase this temperature range, and may well contribute to reduced friction. No production of dioxins can be expected to occur at these temperatures.

b) Heating operations

Roasting and micronising operations involve temperatures until 180°C that is still not high enough to generate dioxins. Only the source of the heat may be of concern. Distillation of fats, oils and fatty acids, as a purification process, is conducted under reduced atmospheric pressure such that the highest temperatures reached are about 200 to 220°C which is not enough to generate dioxins.

Drying of feed materials such as green forage, sugar beet pulp or citrus pulp, potatoes or grains, may involve atmospheric temperature air flow or hot air generated by a non-polluting source, *i.e.* electric heating or heat exchange. Under these circumstances no dioxin contamination can be expected. However, other drying methods involving a direct contact between feed materials and an air flow heated by a direct combustion process and carrying combustion products (gases, smoke) may constitute a considerable pollution source highly dependent on the nature of the fuel used. Whereas natural gas is considered as a clean energy source, other sources (*i.e.* oil and derivates including additives, pit-coal, wood), may generate dioxins during the combustion process, especially if combustion is uncomplete. The particular case of the Anaerobic Pasteurising Conditioning (APC-treatment), which involves heated steam with the presence of combustion gases, should be carefully considered in this regard.

c) Physico-chemical steps

Chemical treatments or reactions (acidic, alkaline, oxidative) applied to certain feed materials to improve their nutritional value or other characteristics, do not use or generate temperatures above 120°C.

Extraction of oil from oilseeds, palm kernels or coconut products in the oil industry, but also of animal fat from meat and bone meals in the rendering industry, implies the use of organic solvents. The presence of dioxins as solvent contaminants, but also the eventual genesis of these compounds from chemical reactions occurring between the solvent (*i.e.* organochlorine) and feed materials, may contribute to the contamination of feedingstuffs.

2.4.3. Collection, transport and storage of feed materials and feedingstuffs

Contamination can occur during collection of feed materials from the fields or industrial sites, as well as when open containers are used for selected waste deposits (*e.g.* polluted waste cooking oil and the dioxin crisis in Belgium). Loading and unloading operations are critical steps where contamination can occur. In addition, generally, transport is not operated in dedicated specific means. For instance, tanks used for industrial (non food / non feed) products can be utilised to transport fat and oils for feed use. Use of paints containing PCBs in containers for transport and storage represent an additional risk for the products.

2.5. Other contamination sources

Any direct contact of feed materials or animals to materials, equipment or litters (sawdust can be used in the beddings of pigs and cows) made of wood treated (preserved or coated) with chemicals that may contain dioxin (pentachlorophenol), constitutes a potential source of contamination. Accidental pollution of feed materials by dioxins may occur from the localised spread out into the agricultural environment of PCBs normally used as heat exchangers but recycled as lubricants, but also from the uncontrolled combustion of wasted plastic/rubber materials (chlorinated compounds).

3. MAIN FEED MATERIALS USED IN EUROPEAN FOOD PRODUCING ANIMALS' DIETS

The following describes the various EU production systems (standardised intensive, extensive, quality certified or organic), for each of the animal categories identified. Although the diets described here represent classical and usual diets for European production of different food producing animals, there exists a wide range of other possible feed materials used in Europe as well as in third countries that represent a limited percentage of the ration and correspond to local and circumstantial supplying conditions.

Unfortunately, the existing data do not allow consideration of the contribution of individual ingredients to the total dioxin content of the diet. For this reason, dietary components are specified only in terms of groups of feed materials for which sufficient data are available.

From a practical point of view, feed materials have been grouped into three main categories. Each category has been further divided into a limited number of sub-groups (for instance, data concerning wheat, barley and corn appear under “vegetable feed materials” and “cereals”):

A. Vegetable feed materials

1. Roughages
2. Roots and tubers
3. Cereals and seeds
4. By-products of plant origin
5. Vegetable oils

B. Feed materials of animal origin

1. Fish oil, fish meal
2. Animals fat, meat and bone meal
3. Milk products

C. Other feed materials

1. Binders and anticaking agents
2. Trace elements
3. Macrominerals

This classification will be used in the tables all along this report.

3.1. Ruminants

Feed materials and consumption are highly dependent on resources and rearing conditions.

Ruminant rearing is usually linked to regional characteristics and particularly to availability of forages. For this reason, rearing practice in the EU countries are very different, depending on climate (which affects forage availability), intensification level, type of production and breed. Wet temperate zones but also cold or warm semi-arid temperate areas are encountered within European Union. Consequently, according to the type of livestock production, the theoretical intake of forages and concentrates under different feed regimes can vary considerably and for this reason, different scenarios have to be considered. They are summarised in table 1.

Table 1 Different rearing scenarios for ruminants and their respective diet composition

SCENARIO	**Diet composition (in % dry matter)**	
	Roughage**	**Concentrate**
Extensive rearing	**80-100**	**0-20***
Semi-intensive rearing	**65-90**	**10-35***
Intensive rearing	**(20***) 40-80**	**20-60 (80***)**

* in winter the intake of concentrate is higher than in summer due to the reduced availability of forages.
** mainly pasture, hay and silage
*** beef cattle in feedlots

The kind of roughage fed depends on availability (area, season).

The level of concentrates in the diet is a function of animal performance (milk yield/weight gain) and is aimed to fulfill the energy and protein requirements of the animals. The concentrates are compound feedingstuffs made from different feed materials.

The composition of concentrates is affected by the basal diet, feed costs and fulfilment of technological requirements. Some examples of concentrate composition are given in table 2.

Table 2 Examples of concentrate composition, for ruminants

<table>
<tr><th colspan="3" rowspan="3">Feed materials</th><th colspan="4">Concentrates N°</th></tr>
<tr><th>I</th><th>II</th><th>III</th><th>IV</th></tr>
<tr><th colspan="4">Percentage</th></tr>
<tr><td>A3</td><td colspan="2">Cereals and legumes</td><td>26</td><td>55</td><td>64</td><td>62</td></tr>
<tr><td rowspan="2">A4</td><td rowspan="2">By products of plant origin</td><td>Soybean meal</td><td>10</td><td>14</td><td>15</td><td>15</td></tr>
<tr><td>Other by products</td><td>60</td><td>25</td><td>10</td><td>10</td></tr>
<tr><td>B1</td><td colspan="2">Fish meal</td><td>-</td><td>-</td><td>5</td><td>5</td></tr>
<tr><td>B2</td><td colspan="2">Fat*</td><td>-</td><td>2</td><td>2</td><td>4</td></tr>
<tr><td>C</td><td colspan="2">Premix**</td><td>4</td><td>4</td><td>4</td><td>4</td></tr>
</table>

* fat can include fat of animal origin and/or of vegetable origin. However for further calculation, it will be considered as exclusively made of animal fat.
** includes minerals, trace elements, vitamins and other feed additives

3.1.1. Bovines

3.1.1.1. Extensive rearing

The animals are kept on pasture for all the year (or at least 4 to 8 months). They are housed in the cold periods when the grass production is not sufficient. The main feed source in summer (often the only source) is pasture, which can be turned or free. During lactation, complementary feed can be given to the animals (premixes and energetic sources, cereals, molasses and proteins).

(1) Milk and meat production

During the summer period, animals are kept outside and the diet is therefore mainly based on fresh grass (90 to 100% of the diet) whereas concentrate can be given (but not always) at up to 10% of the diet.

During the winter period, animals are housed for about 4 to 8 months. Fresh grass is replaced by grass hay and silages representing 80 to 90% of the diet. The use of concentrate increases up to 10 to 20% of the diet. The consumption of concentrate is additionally strongly increased when forage availability (hay and silages) is low on the farm or when daily milk production is increasing. For this reason the intake of mixed feeds in the housing period may vary greatly.

Beef cattle are predominantly pasture-fed in summer, with concentrates fed in early spring and late autumn.

(2) Nursing cows

The availability of forages due to weather conditions strongly affects the feed regimen for nursing cows, which Dry Matter Intake (DMI) ranges from 10 to 12 kg.

In summer the typical diet is based on pasture partially with varying amounts of hay or straw and mineral vitamin supplement.

In winter the diet is based mainly on silage, partially with lower amounts of hay. The animals receive up to 2 kg of concentrate.

3.1.1.2. Semi-intensive rearing

The animals are housed from the late autumn to the spring season

(1) Milk production

Typical of humid and alpine temperate zones, the animals' diet during the summer season is based on pasture, but supplementation with concentrate (25-30% of DMI) is common practice. During the winter period animals are housed for about 5 to 8 months with diet based on silage, partially also hay and concentrate (30-35% of DMI). The percentage of concentrate inclusion in the diet is positively related to milk yield.

(2) Meat production

When pasture productivity is high and grass has a high nutritive value, cattle diets can be composed almost entirely of fresh grass and consequently the intake of concentrate is low (around 1 kg/head/day for animals between 6 to 12 months of age) or limited to self feeding of minerals and liquid feed (urea) based on molasses.

In summer and particularly in autumn the production of pasture decreases and an energy supplementation is required. Molasses based concentrates or cereals can be given to the animals during the finishing period (last 3 months). The amount of concentrate ranges from 2 to 3 kg/head/day, according to the fattening status of the animals. During winter time the animals eat silages and hay with lower supplementation of concentrate.

3.1.1.3. Intensive rearing

(1) Milk production

Animals can be reared in fixed stalling or in free stalling. Roughage constitutes of grass or legumes (alfalfa, fresh, as silage or hay) or corn silage. In the most productive areas of Europe, pasture is also available in summer. Forages are usually produced in the farm, but sometimes they can be bought from other places. Silages and hay account for 50-80% of DMI, the remaining part being constituted by mixed feeds (concentrates up to 60%).

(2) Meat production

In Europe, diets are based mainly on silages (corn, grass) with low levels of straw or hay, and an energy and protein supplementation. During the fattening phase, the dry matter intake is about 2.0 % of live weight.

In some areas, a special type of beef cattle production, called “baby beef” system, exists. In this case, the diet is based on cereals (mainly barley). Only a minimum daily supply of fibrous feed is necessary and no green forage, hay or corn silage are used in the diet.

Beef cattle can also be fed in “feedlots”. In this case, the main ingredients of this diet are cereals, by-products of cereals and soybean, given in concentrates representing about 80% of the diet.

3.1.1.4. Types of diets

All the feeding situations described above for bovines can be summarised in the tables 3 and 4:

Table 3 Diet composition for dairy cows, expressed in percentage on a dry matter basis

		Milk yield (kg/day)				
		5-10 (and dry cow)	5-10 (and dry cow)	15-25	25-35	≥35
Feed materials		Diet composition in percentage				
		n° 1	n° 2	n° 3	n° 4	n° 5
A1	Roughage	100	90	75	60	40
	Concentrate	0	10	25	40	60
		Dry Matter Intake (kg/day)				
		9-12	9-12	15-18	20-22	≈25

Table 4 Diet composition for beef cattle, expressed in percentage on a dry matter basis

			Average daily gain (g/day)			
			400-800	800-1200	>1200	Feedlots
Feed materials			Diet composition in percentage			
			n° 6	n° 7	n° 8	n° 9
A1	Roughage	Corn silage	-	35	70	-
		Others	80	40	-	20
	Concentrate		20	25	30	80

3.1.1.5. Veal calf (pre-ruminant stage)

The diets for calves are based on milk replacers.

Milk replacers are made by adding animal and vegetable fat (200g/kg dry matter) to skimmed milk. It is, however, possible to feed calves with "milkless" powder in which skimmed milk is replaced by whey proteins, caseins, soybean by-products. A minimum daily supply of fibrous feed is necessary for calves over two weeks of age, and the quantity is raised from 50 g to 250 g/day from the 8^{th} to 20^{th} week of life (Commission Decision 97/182/EC[5] amending the Annex to Council Directive 91/629/EEC[6] laying down minimum standards for the protection of calves). The amount of milk replacers ingested increases from 550-700 g dry matter per day in the first week until 3000 g dry matter per day at the end of the fattening period.

The total diet consists on a average of 90% milk replacer and 10% roughage (diet n°10, used for calculation in tables B11 and B12).

3.1.2. Other ruminants

The previous described scenarios can fit also for sheep and goats. For small ruminants the DMI as forages can be relatively higher than for bovine.

The meat sheep systems can be categorised as either lowland, which are intensive and involve housing in winter, or hill-farming systems, which are much more extensive. Lowland systems are pasture-based in summer, but extensive use is made of supplements such as hay, silage, straw, turnips and concentrate pellets. The most intensive form is for early lamb production, in which ewes lamb indoors and are fed generously to maximise milk production, with lambs creep-fed on concentrates, early weaned and fattened indoors on concentrate-based diets. Hill systems are much more extensive and based exclusively on forage available on rough, hill grazing for ewe and lamb, possibly with concentrate, hay and turnip supplementation during times of forage shortage. For sheeps, usually grown on pasture, the data retained for extensively reared animals can be used, with an estimated DMI around 3-4% of live body weight.

The dairy sheep breeding can be considered a semi intensive system with the largest part of animals lambing in autumn (except 30-40% in late winter). Grazing is the major forage source except 2-3 months in winter when hay and some silage are used; concentrate range from 20 to 40% of DMI according to forage availability and milk yield. The DMI can represent as much as 5% of body weight. For 3-4 months of dry season (summer) the animals are dry and fed crops by-products.

For riverine buffaloes the same conditions as those described for extensive, semi-intensive reared cattle can be used, assuming a DMI by adults animals of 14-16 kg in relation to the milk production. Nevertheless many buffalo herds are at present reared in a similar way to intensive dairy cows system *i.e.* large of use of corn silage (40% DMI) hay and concentrate (30% DMI each). It must be noted that the soil intake through drinking water from ponds or rivers and through grazing may be considerable but only for the extensive system.

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5 OJ n° L 076 of 24.02.1997, p. 30

6 OJ n° L 340 of 11.12.1991, p. 28

3.1.3. Soil ingestion aspect

Soil ingestion depends on the abundance and quality of pasture and animals' density at pasture. If grass is vigorous, the animals eat the highest foliaceous parts and the soil ingestion during grazing is low. If pastures are poor (or cattle density too high), the animals graze also the parts near the ground and ingest greater amount of soil. The Danish Veterinary and Food Administration (Danish Plant Directorate), estimated a daily soil intake of 0.225 kg for cows with 18,225 kg of dry matter intake (DMI) (1,23%). According to Fries *et al.* (1982) soil ingestion can represent from 0,14% up to 2.40% of dry matter, and in worst conditions a bovine of 600 kg bw would ingest 480 g of soil/day. Mayland (1975) reported, for young bulls, a case limit of soil intake of 18% of DMI.

Corn for silage, after being cut, is not spread onto soil like grass before ensiling or sun-curing, but it is immediately machine chopped and processed. For this reason soil contamination of corn silage is lower than that of grass hay or ensiled grass. The use of artificially dehydrated forages as substitute for sun-cured hay also can reduce the level of dioxin contamination derived from soil, if the combustion process does not emit dioxins.

For riverine buffaloes the intake of soil in suspension in drinking water or through grazing could be considerable, but reliable data are not available.

3.2. Pigs

Most of the EU pig production is intensive. Only about 1.5% of sows, used for reproduction purposes, are raised outdoor, in particular in the United Kingdom and in France (Le Denmat *et al.,* 1995). The following pig categories/diets have been identified:

(1) Piglets up to 1 month of age are generally suckled by their mother and received very few dry feeds which amounts to a maximum of 1 kg creep feed for the whole month. This diet is based on cereals and protein-rich ingredients including dried skimmed milk (2-10%), dried whey (2-15%), refatted dairy products (2-10%). Early weaned piglets from 3-4 days of age could be fed diets using higher proportions of milk substitutes. The younger the piglets are, the higher is the proportion of milk products in the diets

(2) The young animal diets may include the following feed materials: cereals, soybean meal, fat (up to 8%), fish meal (up to 5%) and minerals. Meat and bone meal can replace soybean meal up to 2 to 5%. Manioc can also be used as a cereal substitute up to a level of 20%. Examples of diets for piglets up to 2 months of age are given in table 5.

Table 5 Examples of diets for piglets aged up to two months in percentage.

Feed materials			Diet composition (in percentage)		
			1	2	3
A3	Cereals	Barley, Maize, Wheat	55	59	60
A4	By-products of plant origin	Soybean meal	25	24	21
		Other by-products	11	-	12
B1	Fish meal		5	5	2
B2	Fat*		-	8	2
C	Premix **		4	4	3

* fat can include fat of animal origin and/or of vegetable origin. However for further calculation, it will be considered as exclusively made of animal fat.

** includes minerals, trace elements, vitamins and other feed additives

(3) For fattening pigs (growing or finishing) from two months until slaughter, the diet includes cereals, wheat bran, corn gluten feed, molasses and peas, meat and bone meal, animal fat, soybean meal, and other feed materials including minerals. Manioc can be used, as for piglets, as energy source to substitute cereals up to a level of 40% in the diet of growing pigs. In some particular cases, fattening animals receive large amounts of liquid whey and/or fresh dairy by-products. In case of the production of heavy pigs, up to 170 kg live weight, higher amounts of fibrous materials can be introduced, supplied by by-products of cereals, seeds and sugar.

Some variations of a pig diet are given in table 6.

Table 6 Some typical diets for fattening pigs and gilts in percentage

Feed materials			Diet composition (in percentage)				
			4	5	6	7	8
A3	Cereals and legumes	Barley, Maize, Wheat	74	40	65	54	59
		Peas	-	-	15	15	2
A4	By-products of plant origin	Soybean meal	23	23	14	20	20
		Other by-products	-	30	3	3	9
B2	Meat and bone meal		-	-	-	-	5
	Fat*		-	4	-	5	4
C	Premix **		3	3	3	3	1

* fat can include fat of animal origin and/or of vegetable origin. However for further calculation, it will be considered as exclusively made of animal fat.

** includes minerals, trace elements, vitamins and other feed additives

(4) Diets of pregnant and lactating sows are based on the same feed materials as for fattening pigs. However, they can contain fibrous components such as citrus pulp (0-15 %) dried sugar beet pulp (0-15

%) and alfalfa meal (up to 32 %). Manioc can be used as an energy source up to 40%.

Additionally, for animals kept outdoor, which are mainly productive gilts and sows (pregnant and lactating), the diet includes substantial intake of green forage (2 to 5 kg/day or up to 1 kg DM) and soil (200 to 500 g/day) during rooting.

Six examples for lactating sows and pregnant sows are presented in table 7.

Table 7 Examples of diets for lactating sows (n°9, 10 & 11) and pregnant sows (n°12, 13 & 14) expressed in percentage

Feed materials			Diet composition (in percentage)					
			9	10	11	12*	13*	14
A1	Roughage		-	-	-	-	-	32
A3	Cereals and legumes	Barley, Maize, Wheat	63	44	47	42	17	25
		Peas	16	14	8	12	12	-
A4	By-products of plant origin	Soybean meal	15	19	20	3	11	10
		Other by-products	-	12	19	40	53	30
B1	Fish meal		2	2	-	-	-	-
B2	Fat **		-	5	3	-	5	1
C	Premix ***		4	4	3	3	2	2

* animals fed restrictively

** fat can include fat of animal origin and/or of vegetable origin. However for further calculation, it will be considered as exclusively made of animal fat.

*** includes minerals, trace elements, vitamins and other feed additives

3.3. Poultry

The composition of poultry diets is close to that of pigs. Diets of young poultry (growing and fattening broilers, turkeys and other poultry) are similar to those of piglets; those of adult poultry (layers, poultry for reproduction) are like those of adult pigs.

Cereals, legumes and by-products (such as extracted oil meals), cereal middlings, corn gluten feed etc. are the most frequent feed materials. Fats, manioc, some feeds of animal origin and additives vary according to animal diets. The proportion of different ingredients varies according to animal requirements along the growing period. Table 8 gives three typical diets for broilers, layers and turkeys. Similar diets are fed to ducks, geese, pheasants, guinea fowl and other poultry.

Table 8 Typical diets for food producing poultry (broiler (diets n° 1, 2 & 3), layer (diets n° 4, 5 & 6), turkey (diets n° 7, 8 & 9)) expressed in percentage

Feed materials			Diet composition (in percentage)								
			1 [1)]	2 [2)]	3 [2)]	4	5	6	7 [3)]	8 [4)]	9 [5)]
A1	Roughage		-	-	-	3	3	5	-	-	-
A3	Cereals and seeds (legumes)	Cereals	58	70	50	70	60	50	47	60	50
		Legumes (peas, beans)	-	-	5	-	-	10	-	-	5
A4	By-products of plant origin	Soybean meal	30	18	21	10	12	8	40	30	20
		Other by-products	-	-	10	5	14	16	5	-	14
B1	Fish meal		5	-	-	3	-	-	3	-	-
B2	Meat and bone meal		-	3	-	-	3	-	-	3	-
	Fat*		3	5	10	-	-	2	2	4	8
C	Limestone		-	-	-	7	6	7	-	-	-
	Premix**		4	4	4	2	2	2	3	3	3

[1)] Starter period (0-2 weeks); [2)] Grower period (3-5 weeks); [3)] Starter period (0-4 weeks); [4)] Grower period (5-8 weeks of age); [5)] Fattening period (> 8 weeks of age)

* fat can include fat of animal origin and/or of vegetable origin. However for further calculation, it will be considered as exclusively made of animal fat.

** includes minerals, trace elements, vitamins and other feed additives

Typical EU-production conditions are characterised by indoor keeping. In some cases (layers, ducks, geese etc.) free-range production increased. The proportion of free ranged poultry depends on poultry species and categories as well as the country varying between less than 5% (broilers, turkeys) and more than 50% (ducks, geese) of the total poultry population.

Free ranging of poultry are typical production conditions of organic farming. It is not allowed to feed feeds of animal origin (*e.g.* meat and bone meal), extracted oil meals, technical amino acids, most of the feed additives and further feeds in organic farming systems. Furthermore free ranging poultry may consume forages, insects and soil. The daily forage intake of layers amounts to about 35 g (legumes, grass, herbs etc., Mehner 1968.). About 20g of feed comes from animal origin (insects, worms etc., Krax 1974, Marks 1985). Free ranging hens consume about 4g protein of animal origin per day (Krax 1974).

Information of soil intake of free ranging poultry varies between 2 and 10 g per laying hen and day (Mc Kone 1994, Petreas *et al.* 1991, Stephens *et al.* 1992, 1995). Soil intake depends on animal numbers per free ranging area. It increases if more animals are kept per area (Schuler *et al.* 1997a).

3.4. Rabbit

The EU production of rabbits is essentially intensive. Animals are kept in wire cages, and therefore have no access to other material than the offered diet. However, rabbits raised in wooden cages or lactating does raised in cages fitted with wooden nest for their progeny can chew the surrounding wood material, which, if treated with chlorinated preservatives, could represent an additional source of contamination.

Rabbit feeding is mainly based on compound feeds, which are essentially composed of vegetable (plants) materials including a large proportion of cereals, by-products (from cereals, seeds and sugar), dehydrated alfalfa meal, straw and mineral supplements. Similar ingredients are used for does and fattening rabbits. Low or high fat content are also used in feeds mainly from vegetable origin (oil), and mineral matter can contain technological agents to facilitate pelleting of compound feed.

There are slight variations between the diet of rabbits at the growing/finishing stage and the diet of reproductive animals (doe) which typical compositions are given.

Table 9 Typical diets for rabbits (for meat production (diet n° 1 & 2), for reproduction purposes (diet n°3) expressed in percentage

Feed materials			Diet composition (in percentage)		
			1	**2**	**3**
A1	Roughage		**3**	**3**	**3**
			17	**15**	**15**
A3	Cereals		**25**	**29**	**33**
A4	By-products of plant origin	Soybean meal	**8**	**8**	**8**
		Other by-products	**42**	**36**	**36**
B2	Fat*		**1**	**5**	**1**
C	Premix**		**4**	**4**	**4**

* fat can include fat of animal origin and/or of vegetable origin. However for further calculation, it will be considered as exclusively made of animal fat.

** includes minerals, trace elements, vitamins and other feed additives

3.5. Fish

Fish diets are well defined and are made of fish meal, fish oil and vegetables, each of these feed materials varying depending on the target fish.

Fish meal and fish oil are essential dietary feed ingredients for all industry-produced aquafeeds for carnivorous fish, and to a lesser extent, for omnivorous fish and shrimp species. In 1992, 61.2 % of the fish meal used in aquafeeds was consumed by carnivorous fish species such as salmon, trout, eel, yellow tail and sea bream, 32% by shrimp whilst 6.8% was consumed by omnivorous species (Tacon, 1993). The highest fish meal production per country was found in Peru (1.2 million tonnes), followed by Chile, Japan, USSR and USA. Denmark was the highest fish meal producer within the EU (260 000 tonnes), followed by Spain (135 000 tonnes) and the United Kingdom (51 000 tonnes). It was estimated that between 816,000 and 873,000 tonnes of fish meal and between 190,000 and 205,000 tonnes of fish oil were used in aquafeeds in 1990. This is equivalent to between 13 and 15% of the total world supply of fish meal and fish oil. The fish meal usage was expected to increase by 50% to ca. 1.2 million tonnes in 2000 and fish oil usage by 77% to ca. 0.36 million tonnes per year. Assuming that global fish meal and fish oil production will remain at their present level, this would mean that in 2000 about 20% of the total world supply of fish meal and fish oil would be consumed by aquafeeds. Recent data confirm these expectations (Eurostat, 1999). The total volume of fish meal used in Europe in 1997 was 1,410,000 tonnes.

Dietary inclusion levels of fishmeal usually range from 4-5% in production diets for channel catfish to 75% in larval diets for marine finfish and eel or turbot production diets. Similarly, dietary fish oil supplement levels range from 1-2% within production diets for omnivorous species to 15-30% within expanded salmon diets. Examples of a carnivorous species diet (*e.g.* salmon) and a non-carnivorous species diet are given in table 10. Fish meal and fish oil are not used in herbivorous fish species diets.

<u>Table 10</u> Description of the usual diets for omnivorous and carnivorous fish species in percentage

			Omnivorous species	**Carnivorous species**
Feed materials			**Fish diet expressed in %**	
A3	Cereals		**30**	**11**
A4	By-products of plant origin	Oilseed meal	**56**	**7**
		Maize gluten meal	**-**	**5**
B1	Fish meal		**10**	**50**
	Fish oil		**2**	**25**
C	Premix*		**2**	**2**

* includes minerals, trace elements, vitamins, single cell proteins and other feed additives

4. CONTAMINATION LEVELS OF FEED MATERIALS - DATA AVAILABLE

4.1. Detection and analysis - Technical considerations

Dioxins are normally found as complex mixtures in varying composition in the different matrices. This requires a highly sophisticated analysis, because it is indispensable to separate the toxic congeners (bearing 2,3,7,8- chlorine substitutions) from the non-toxic. Usually, PCDDs/PCDFs are determined by capillary-GC/MS (gas chromatography / mass spectrometry) methods. Whereas many environmental samples (as soil or sewage sludge) can be analysed with low-resolution mass spectrometry, measurements of feed, food and human milk or tissue samples have to be performed at ultra-trace levels. Therefore, if food or feedingstuff samples are to be analysed reliably in the range of the normal background contamination, the application of high-resolution mass spectrometry is necessary.

For comparison of analytical results, the limit of detection (lowest limit for qualitative identification, without possibility to quantify the amount) and/or limit of determination (lowest limit for quantification) have to be taken into account. Analytically, all 17 congeners with 2,3,7,8-substitution must be determined. For calculation of the TEQ value, the results of each of these congeners is multiplied by the specific TEF factor and then added up. In most cases, a few of the 17 congeners are below the limit of detection and/or limit of determination. This can become critical if many congeners are not determinable or if the toxicological most important congeners are not found. Some laboratories are used to calculate the contribution of not detectable congeners to the TEQ as "0". As a consequence, low dioxin contents could have been the result of really low levels of the sample or of insufficient detection/determination limits, without considering these detection/ determination limits in the final TEQ calculation. To make sure that low dioxin levels are really the result of low levels in the sample, the concept of tolerances "as upper bound limit of detection" or "upper bound limit of determination" was developed. This concept demands the inclusion of the full limit of detection or determination instead of "zero" for not detectable substances. It should be applied generally, with a clear preference of "upper bound limit of determination" rather than upper bound limits of detection.

A practical example should demonstrate the problem: table A16 summarises an overview of dioxin contents in kaolinitic clay from available reports. For montmorillonite/bentonite, a laboratory has found < 1.9ng I-TEQ/kg. Thus, obviously dioxins were not detectable with a limit of determination of 1.9ng I-TEQ/kg. For the same group, a laboratory of the same country (maybe the same laboratory?) found 1.7ng I-TEQ/kg. It remains unclear whether the range of 1.5 to 2ng I-TEQ/kg was the practical limit of determination of that laboratory. This may be acceptable in a crisis situation (*e.g.* after the first finding of the contamination of kaolinitic clay) to see whether there are other highly contaminated samples, as well. However, these values cannot be used for definition of the background contamination, as the applied method is obviously not suitable for this purpose. Moreover, the method is not suitable for determinations in the range of the tolerance of 0.5 ng WHO-TEQ/kg which was set in response to the finding of this contamination.

When the limits of determination are high for the decisive congeners, it results in high numbers of TEQ. This has to be considered for the definition of background contamination. Especially the use of low-resolution mass spectrometers in feed materials/feedingstuffs analysis or a low weight-in quantity of a sample (for a quick and easy analysis) can cause relatively high values of dioxin contents as upper bound limits of determination. This cannot be seen from a reported TEQ level without knowledge about the results of the individual congeners. Thus, for definition of a background contamination, published data must be reviewed critically to avoid that relatively high values are included only as a result of insufficient detection limits.

The Committee is in line with the recommendations of the report of an EU mission to Brazil (of July 1999) in connection with the citrus pulp case (European Commission, 1999c). For the control of the tolerance of 0.5ng WHO-TEQ/kg (as upper bound limit of determination) in citrus pulp and lime, it was demanded that the registered laboratories should be able to meet the following requirements:

- demonstration of the performance of a method in the range of the tolerance, *e.g.* 0.5x, 1x and 2x the tolerance

- limit of detection should be in the range of about one fifth of the tolerance, to make sure that acceptable coefficients of variations are met in the range of the tolerance

For feed materials of vegetable origin in general, a limit of determination of approximately 0.1ng WHO-TEQ/kg dry matter seems to be appropriate to differentiate reliably between samples with elevated dioxin levels and background contamination. However, to follow time trends of background contamination in those matrices, the limit of determination should be at least a factor of 10 lower. For animal products of land origin and for fish and fish products, a limit of determination of 0.1ng WHO-TEQ/kg fat (as upper bound limit of determination) seems to be appropriate for both the above mentioned goals.

The qualification of the laboratories is an essential parameter. So far, laboratories applying GC/MS methods have shown that reliable determination of all 17 PCDDs/PCDFs congeners with 2,3,7,8-substitution is possible even in ultra trace levels. However, the successful participation in intercalibration studies for *e.g.* soil or sewage samples does not necessarily prove the competence also in the field of food or feedingstuff samples with their lower contamination range. Another difficulty arises from the lack of reference material with certified dioxin content which would be helpful for internal quality control of laboratories. So far, no such material is available. With this regard, the Committee welcomes the call published recently by the European Commission (2000/C 290/05) for proposals for indirect RTD actions under the specific programme for research, technological development and demonstration on competitive and sustainable growth[7],

[7] OJ n° C 290 of 13.10.2000, p. 4

which invites for submission of proposals to support the development of Certified Reference Materials, in particular in the field of environmental contaminants in food and animal feed (topic IV.20) and specifically for PCDDs, PCDFs and PCBs in food and feed products.

Bioassays were developed as rapid screening methods. These bioassays can give only a TEQ range as final result, but do not give any congener specific values which would allow a pattern discussion. To evaluate the reliability of methods, numerous statistical data must be presented as the limit of determination or the coefficient of variation at different relevant levels. Numbers on false-positive or false-negative results are important criteria for screening tests, as well. Last but not least use of these bioassays in collaborative studies could demonstrate the performance. So far, there is a lack of data to prove the general comparability of the bioassay results to well-documented GC/MS methods.

In the past, PCB analyses mainly focused on the determination of the marker congeners 28, 52, 101, 138, 153 and 180, which are the predominant PCB congeners found in humans and food stuffs of animal origin. However, the toxicity of these PCB congeners is relatively low. On the other hand, data for those dioxin-like PCB congeners, which are much more important because of their toxicological potencies, are still scarce.

4.2. Evaluation of the contamination of feed materials

In order to use consistent figures for the calculations of dioxin contents of each animal category diet (chapter 5), low and high contamination levels as well as a mean value of dioxin burden of the feed materials have been established on the basis of the data available. These data are available in Annex A. The figures are expressed in ng WHO-TEQ / kg dry matter. As the database for dioxin-like PCBs is scarce, low, mean and high values were derived only for dioxins.

It must be underlined that the choice of the highest values was somewhat arbitrary due to the scarcity of the data and limited information on the origin and conditions of analysis of the samples. This choice was made considering very severe in not the worst situations.

4.2.1. Vegetable feed materials

4.2.1.1. Roughage (forages, conservates and cereal straw)

Very limited data are available concerning the contamination of grass and other fodders. Table A3 summarises data (European Commission, 1999a) concerning dioxin level in some European rural, non-contaminated areas as well as in areas known to be contaminated. The values reported range from 0.13 to 2.1 ng WHO-TEQ/kg DM. Other results, obtained recently by Malisch (2000b, see table A1), show values ranging from 0.04 to 0.51 for non-contaminated samples and from 0.84 to 24.1 for contaminated samples (clearly identified as not accidentally polluted).

On the basis of the available data for roughage, low level, high level and mean level retained for calculation were identified and are respectively 0.1, 6.6 and 0.2 ng WHO-TEQ/kg dry matter

One paper with recent data concerning grass silage is available that indicates mean contamination levels of 0.201 ng I-TEQ/kg DM (upperbound detection limit) and of 0.137 ng I-TEQ/kg DM (limit of determination), with respective ranges of 0.120-0.650 and 0.070-0.630 (Monitoring Schleswig-Holstein, 1998), which are consistent with the preceding data for forages. Therefore, taking into account the scarcity of the information, the levels chosen for forages have been retained for the processed materials (silages, hay) as well:

Roughage	Low	0.1 ng WHO-TEQ/kg dry matter
	Mean	0.2 ng WHO-TEQ/kg dry matter
	High	6.6 ng WHO-TEQ/kg dry matter

Remark: As sun-curing and silaging are not polluting operations *per se*, (see previous comments in chapter 3.1, introduction), soil may represent an additional contamination source.

4.2.1.2. Roots and tubers

No data are available apart from two analyses performed on manioc reported by Schöppe and Kube-Schwickardi (1998, see table A6), and two analyses from Malisch (Malisch 2000b, see table A1). As the absorption and transport of dioxins by the plants is very limited, it can be anticipated that the contamination of roots and tubers is very low if the soil is not contaminated. Moreover the use of these materials in pig and ruminant diets is dependent on local resources and limited to certain period of the year. Therefore no levels have been identified.

However, depending on the weather conditions prevailing at the cropping period, the contamination of roots and tubers by soil may be important. Namely manioc (used as starch source for energy) could be contaminated depending on the harvesting conditions that may convey important quantities of soil, but also processing (drying) conditions. This is illustrated by the value of 0.71 ng I-TEQ/kg dry matter quoted by Schöppe and Kube-Schwickardi (1998).

4.2.1.3. Cereals, seeds, by-products of plant origin

A compilation of the data available is given for cereals and seeds (see tables A1 and A4) and by-products of milling (table A5), starch industry (table A6), sugar industry (table A7), brewery/distillery (table A8) and oil industry (table A9). They are mostly expressed as ng I-TEQ/kg feed. Although only few data are available, they show that on the average dioxin contamination of these materials is relatively low (less than 0.1 ng WHO-TEQ/kg product or dry matter).

More data are required to assess the possible risk of some by-products in animal nutrition, especially for some milling by-products, manioc, sugar beet pulp, molasses and cereal dusts.

In some cases, such as grain dust, higher values were measured (barley dust: 0.330; wheat dust: 0.440 ng I-TEQ/kg DM) which confirms the prevalence of the deposit of dioxins on externally exposed plant organs. However, the average of milling by-products (not specified 0.671 ng I-TEQ/kg DM; Ruoff *et al*. 1999) should not be over-estimated because of a contaminated sample (5.528 ng I-TEQ/kg DM).

Some references (European Commission, 1999b, Schöppe *et al*. 1997) indicate higher values for sugar beet pulp (0.42-0.56 ng I-TEQ/kg; see table A7).

As a summary, the following values have been retained:

Cereals and seeds	Low	0.01 ng WHO-TEQ/kg dry matter
	Mean	0.1 ng WHO-TEQ/kg dry matter
	High	0.4 ng WHO-TEQ/kg dry matter

By-products of plant origin	Low	0.02 ng WHO-TEQ/kg dry matter
	Mean	0.1 ng WHO-TEQ/kg dry matter
	High	0.7 ng WHO-TEQ/kg dry matter

4.2.1.4. Vegetable oils

Referring to the data on dioxin contents of seeds and oil by-products (cakes) (see 4.2.1.3.), *i.e.* feed materials derived from oleaginous plants with high lipid contents or at least residual oil (cakes), the background level is below 0.1 ng WHO-TEQ/kg DM. This indicates a very limited contamination of these plants. Moreover refinery methods contribute to the elimination of these contaminating compounds. Results of Malisch (2000b) confirm the very low contamination of vegetable oils (below 0.1 ng WHO-TEQ/kg of fat). Other data are scarce.

The SCOOP task 3.2.5 provides a few analytical results from only three countries. When compared to results of Malisch (2000b), they appear to be much higher. However it is indicated that these values are around the limit of determination of the method used, which lead to an overestimation of the dioxin contents.

Finally the SCAN has retained the following figures:

Vegetable oil	Low	0.1 ng WHO-TEQ/kg dry matter
	Mean	0.2 ng WHO-TEQ/kg dry matter
	High	1.5 ng WHO-TEQ/kg dry matter

4.2.2. *Feed materials of animal origin*

4.2.2.1. Fish meal

The data presented in table A10 show that fish can be identified as an important source of contamination of feedingstuffs by dioxins, PCBs and dioxin-like PCBs.

Few dioxin analyses have been carried out in fish meal and fish oil. Possibly more have been carried out within the industries but have not been published. The above mentioned table gives an overview of dioxin concentrations found in fish meal and fish oil samples.

The data are relatively consistent. There is a clear difference in contamination levels between fish meal originating from the (south) Pacific (Chile and Peru) and those originating from European waters. The concentrations measured in the latter are 8 fold higher than in the former.

Within Europe no clear difference could be found between fish meal originating from northern waters, *e.g.* around Iceland and the North Sea. The available database may be too small to see such differences. In some samples the dioxin levels have been expressed as Nordic-TEQ or I-TEQ, which means that the TEF values used for dioxins and furans are slightly different than those used in the WHO-TEQ calculation, and, more important, PCB levels have not been taken into account. The data of Vartiainen and Hallikainen (1995) show an average factor of 4.0 between PCB and dioxin TEQ values in fish oil. A similar ratio was found by de Boer *et al*. (1993) in Dutch fish samples. Malisch (1996) reported PCB TEQ/dioxin TEQ ratios of 2.7-23.3 in freshwater fish (eel, pike and roach), with mean ratios of 6-8. However, some eel may have contained exceptionally high PCB levels.

The following ranges and means expressed as dioxin in ng WHO-TEQ/kg have been retained for fish meal (including only PCDDs/PCDFs):

	South Pacific (Chile, Peru)	Europe
Range	0.18 - 2.1 ng/kg fat	0.3 - 47 ng/kg fat
Mean	1.17 ng/kg fat	10.1 ng/kg fat

Considering that the fat represents approximately 12% of the fish meal, the following values (for PCDDs/PCDFs only) expressed in ng WHO-TEQ / kg dry matter (DM) are retained:

Fish meal originating from the South Pacific area (Chile, Peru):

Fish meal	Low	0.02 ng WHO-TEQ/kg dry matter
	Mean	0.14 ng WHO-TEQ/kg dry matter
	High	0.25 ng WHO-TEQ/kg dry matter

Fish meal originating from the European area:

Fish meal	Low	0.04 ng WHO-TEQ/kg dry matter
	Mean	1.2 ng WHO-TEQ/kg dry matter
	High	5.6 ng WHO-TEQ/kg dry matter

To take into account the contribution of PCBs to the total TEQ, the TEQ results reported by references Döring (2000), Anon (2000), Lundebye-Haldorsen and Lie (1999), Guodmundsson (1999), Andunsson (2000), and Anon (1999a) in the table A10 have been multiplied by a factor of 5. Original and corrected data are presented in that table.

The following ranges and means expressed as dioxin + PCB WHO-TEQ/kg on a dry matter (DM) basis have been calculated for fish meal:

Fish meal originating from the South Pacific (Chile, Peru) area:

Fish meal	Low	0.11 ng WHO-TEQ/kg dry matter
	Mean	0.7 ng WHO-TEQ/kg dry matter
	High	1.26 ng WHO-TEQ/kg dry matter

Fish meal originating from the European area:

Fish meal	Low	0.18 ng WHO-TEQ/kg dry matter
	Mean	6.1 ng WHO-TEQ/kg dry matter
	High	28.2 ng WHO-TEQ/kg dry matter

4.2.2.2. Fish oil

The picture for fish oil is similar to that of fish meal: higher contamination levels in European fish oil compared to fish oil of South Pacific (Chile, Peru) origin. By using the data from the table A14, the following ranges for dioxin have been retained (expressed in ng WHO-TEQ/kg fat):

Fish oil originating from the Pacific area:

Fish oil	Low	0.16 ng WHO-TEQ/kg fat
	Mean	0.61 ng WHO-TEQ/kg fat
	High	2.6 ng WHO-TEQ/kg fat

Fish oil originating from the European area:

Fish oil	Low	0.7 ng WHO-TEQ/kg fat
	Mean	4.8 ng WHO-TEQ/kg fat
	High	20 ng WHO-TEQ/kg fat

The same correction has been applied for the PCB concentrations in some fish oils (Anon (2000), Guodmunsson (1999), Andunsson (2000) and Anon (1999a)).

Therefore, the following ranges for dioxin + PCB TEQ data in fish oil (weighted means by using the data from the table A14) expressed in ng WHO-TEQ per kg fat have been calculated:

Fish oil originating from the Pacific area:

Fish oil	Low	0.8 ng WHO-TEQ/kg fat
	Mean	3 ng WHO-TEQ/kg fat
	High	13 ng WHO-TEQ/kg fat

Fish oil originating from the European area:

Fish oil	Low	3.5 ng WHO-TEQ/kg fat
	Mean	24 ng WHO-TEQ/kg fat
	High	100 ng WHO-TEQ/kg fat

4.2.2.3. Meat and bone meal, animal fat

As dioxins are bioaccumulated in animal fatty tissues, one could anticipate that recycling of animal products through rendering would give an efficient concentration process. The analytical results concerning animal fats (see table A13) indicate a range of values (0.5 to 1.5 ng WHO-TEQ/kg of fat) that are higher than those found in most other feed materials of plant origin, but still much lower than in fish products.

The data concerning meat and bone meals, which contain only 7 to 8% of fat, are summarised in table A11. They indicate a low contamination with dioxins. Feathers collected separately at bird slaughter constitute, once processed, a protein source and are used as feed. The dioxin contamination levels of feather meals are similar to those of meat and bone meal.

On the basis of these data the levels of contamination retained by the SCAN are:

Animal fat	Low	0.5 ng WHO-TEQ/kg fat
	Mean	1 ng WHO-TEQ/kg fat
	High	3.3 ng WHO-TEQ/kg fat

Meat and bone meal	Low	0.1 ng WHO-TEQ/kg dry matter
	Mean	0.2 ng WHO-TEQ/kg dry matter
	High	0.5 ng WHO-TEQ/kg dry matter

4.2.2.4. Milk replacers

Milk constitutes an efficient elimination pathway of dioxins in animals, which is reflected by the average contamination found in milk products. However information on the data presented in table A12 are not sufficient to establish levels of contamination.

Dairy products, such as dried whey and skimmed milk, used in milk replacers are defatted materials and therefore considered not contaminated. However, milk replacers are generally based on refatted dairy products (about 20% of fat on dry matter basis) such as refatted whey or refatted skimmed milk. Mixtures (50/50) of animal fat and vegetable oil are used. Therefore, considering that fat represents ca 20% of the milk replacers, the following values are proposed by SCAN for calculation.

Milk replacers	Low	0.06 ng WHO-TEQ/kg dry matter
	Mean	0.12 ng WHO-TEQ/kg dry matter
	High	0.48 ng WHO-TEQ/kg dry matter

4.2.3. Soil and other feed materials

4.2.3.1. Soil

Many studies have been aimed at identifying "hotspots" of contamination, and as a result such locations have been more intensively sampled and analysed than background or base line locations. Data obtained from different European countries have been compiled (European Commission, 1999a). As expected a wide range of concentration values for dioxins was found. It has not been possible to carry out any statistical analysis of available data, as countries or individual reports provided aggregated data covering varying numbers of samples, sampling procedures, periods and locations. However, the analysis of the data shows that in most cases it is impossible to distinguish significant differences in background concentrations of dioxin in rural and urban locations. Major differences were only noted between contaminated and not contaminated sites. Table A15 summarises the range of dioxin concentrations measured in pasture and arable soils in different European countries.

Taking into account the grazing and rearing practices, the potential contamination of the animal feed resources is generally below 3 to 4 ng I-TEQ/kg DM, except for the contaminated areas where a factor of x 1,000 may be encountered. Facing the difficulty to choose a typical concentration value for a "naturally" but highly contaminated soil, the highest concentration appearing in table A15 has been retained as a conservative approach.

Soil	Low	0.5 ng WHO-TEQ/kg dry matter
	Mean	5 ng WHO-TEQ/kg dry matter
	High	87 ng WHO-TEQ/kg dry matter

4.2.3.2. Binders and anticaking agents

The available data are shown in table A16. The dioxin contamination of these various minerals is very low. Referring to chapters 2.1 and 2.3, it is clear that the contamination is highly dependent on the geological conditions prevailing at the mining site, and that the accidents which occurred with kaolinitic clay, ball clay or bentonite are the exception. The upper level retained for this category of feed materials is the maximum permitted level according to Commission Regulation n°2439/99 of 17 November 1999[8] *i.e.* 0.5 ng WHO-TEQ /kg dry matter. The other values have been chosen according to the data listed in table A16.

Binders and anticaking agents	Low	0.1 ng WHO-TEQ/kg dry matter
	Mean	0.2 ng WHO-TEQ/kg dry matter
	High	0.5 ng WHO-TEQ/kg dry matter*

* not analysed

8 JO n° L 297 of 18.11.1999, p. 8

4.2.3.3. Trace elements / Macrominerals / Premixes

The very limited available data are presented in table A17. As premixes are a dilution of trace elements/macrominerals and other ingredients with feed materials like cereals or by-products used as a carrier, their dioxin content is comparable for both categories. Therefore similar values have been retained:

Trace elements, macrominerals	Low	0.1 ng WHO-TEQ/kg dry matter
	Mean	0.2 ng WHO-TEQ/kg dry matter
	High	0.5 ng WHO-TEQ/kg dry matter*

* not analysed

Premixes	Low	0.02 ng WHO-TEQ/kg dry matter
	Mean	0.2 ng WHO-TEQ/kg dry matter
	High	0.5 ng WHO-TEQ/kg dry matter*

* not analysed

4.2.4. Evaluation of the levels of contamination

On the basis of the available data, and the calculated mean value, it can be concluded that the most important contaminated feed materials used in animal feedingstuffs are, by order of importance:

(1) Fish oil and fish meal

(2) Animal fat

(3) All other feed materials.

Soil, although not being *stricto sensu* a feed material, is being ingested by some categories of animals. The soil contamination is very variable, but could become a significant contributor to animal exposure to dioxins, as its contamination can be high.

4.3. Estimation of background contamination of feed materials

All data summarised in table A3 to A17 have been used to identify the level of contamination of the different feed materials and show a wide range of dioxin contents. However, most data (with the exception of the data provided by Malisch, 2000b, tables A1 and A2) do not contain information on two points important for the interpretation of background levels:

- the upper bound limit of determination of the method (see chapter 4.1.)
- whether a possibly contaminated feed material is included

Thus, it is difficult to conclude the range of the normal background contamination from tables summarising all published results and to separate this from elevated levels.

4.3.1. Estimation of background contamination on the basis of feed materials data

To give an orientation in the discussion of the background contamination of feed materials, the Committee chose therefore to use the detailed data of the Malisch study (Malisch, 2000b; Malisch and Fürst, 2000). Here the results of dioxin determinations in 245 feed materials samples are evaluated. These were analysed between 1993 and 1999 in Germany. Almost 80 % of these samples were analysed in 1998 and 1999 in relation to episodes of severe dioxin contamination of feedingstuffs.

From all 245 analysed samples, whose origin was fully identified, 72 samples were related to a specific dioxin contamination (Brazilian citrus pulp pellets; kaolinitic clay; hay from PCP-treated storage rooms; grass fertilised with contaminated Thomas phosphate). The remaining 173 samples were considered to reflect the background contamination and evaluated statistically. When compared to the number of feed materials and ingredients that can enter into the composition of feedingstuffs, only a very limited number of analyses per compound are available. Therefore the collected samples were grouped in three categories and a limited of sub-groups as explained in chapter 3. In addition to the three categories (A, B and C), data are given concerning dioxin concentrations in commercial compound (mixed) feeds (feedingstuffs: category D).

The data of the analysis of the different feed materials groups, separated for contaminated and not contaminated samples and recalculated for the WHO-TEQ content as upper bound determination limit (with inclusion only of PCDDs/PCDFs), are presented in table A1.

The frequency of the distribution of dioxin contamination of feed materials groups A1 to A4 is shown in Figure 1.

It is obvious that the usual background contamination of products of the groups A2, A3 and A4 is below 0.2 ng WHO-TEQ/kg dry matter (air dried or at 105 °C dried; upper bound determination level; only PCDDs/PCDFs included).

Feed materials of the group A1 (forages, conservates and cereal straw) have a tendency to slightly higher levels. This is the result of numerous grass samples which are here included. Grass and leaves provide a large surface area for aerial contamination with dioxins on its wax layer, which is able to absorb PCDDs/PCDFs. In comparison to grass, feed materials of the groups A2 and A3 have a smaller surface, with tubers and roots being contaminated predominantly by soil and cereals and seeds by aerial deposition. The time for growth (season of the year) could have an influence on the dioxin content, as the growth rate is different. To take into account as many parameters as possible, the grass, hay and grass silage samples were taken at different times and reflect rural and highly populated areas, however without known dioxin emittents in the surrounding area. Thus, they do not include highly industrialised areas *e.g.* with steel production.

Figure 1

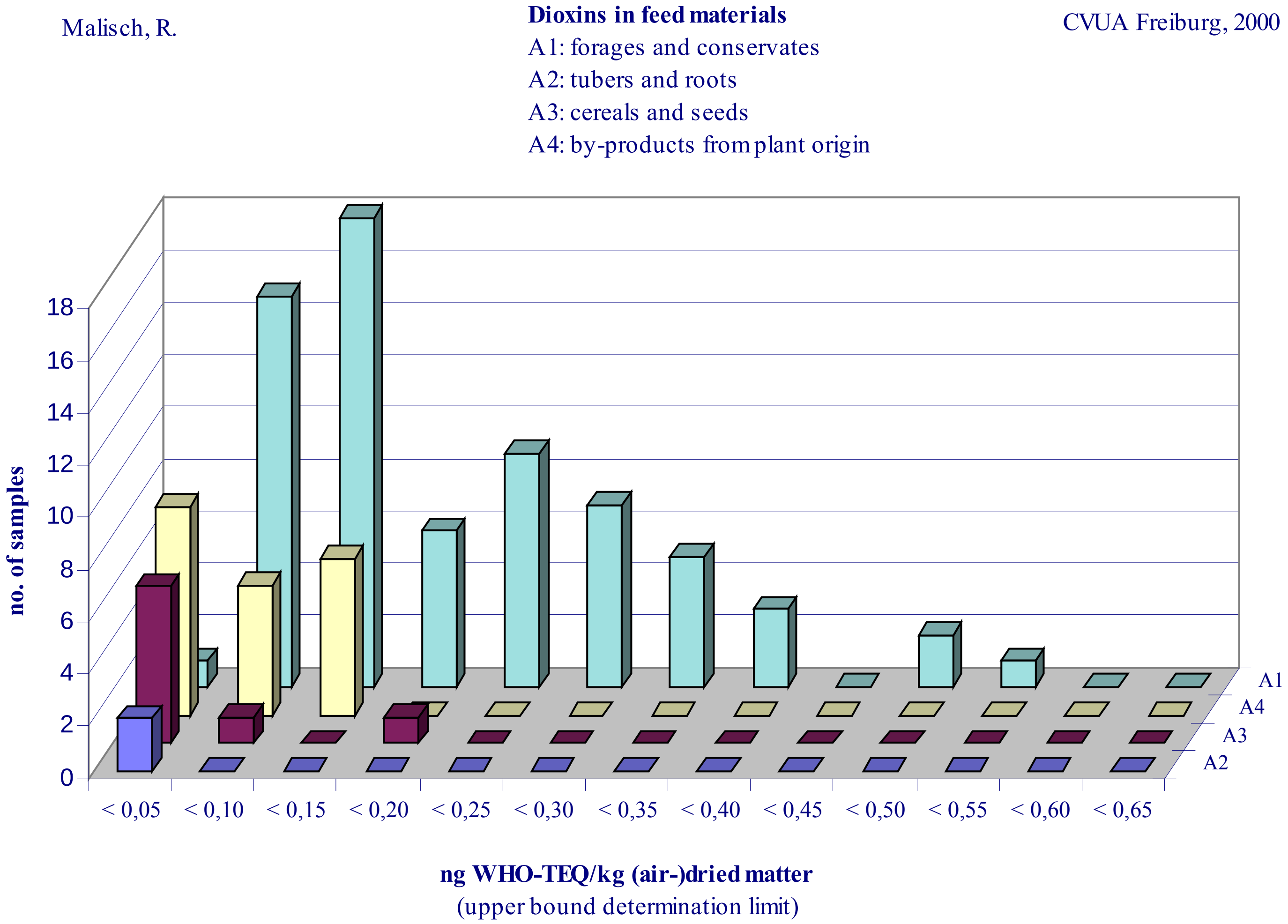
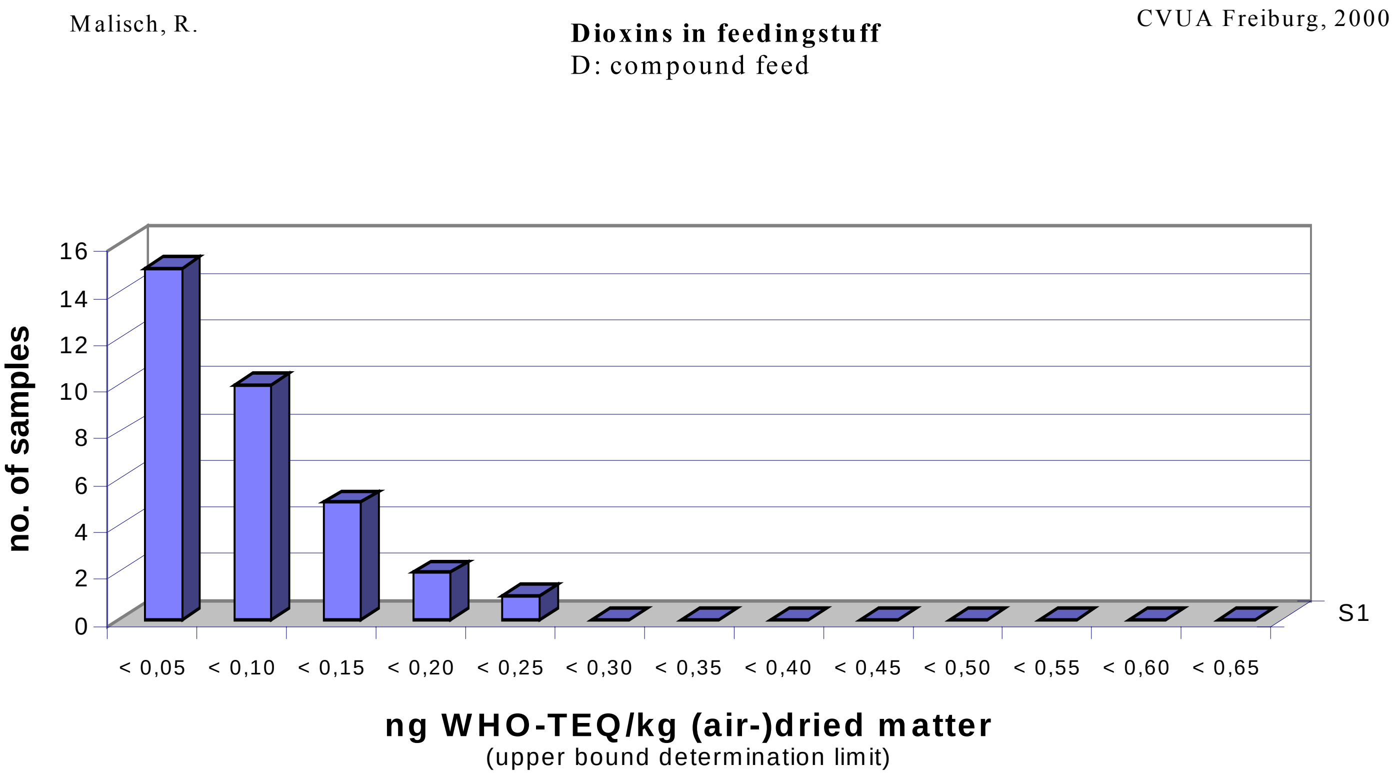

Malisch, R.
Dioxins in feed materials
A1: forages and conservates
A2: tubers and roots
A3: cereals and seeds
A4: by-products from plant origin
CVUA Freiburg, 2000
no. of samples
0
2
4
6
8
10
12
14
16
18
A1
A4
A3
A2
< 0,05
< 0,10
< 0,15
< 0,20
< 0,25
< 0,30
< 0,35
< 0,40
< 0,45
< 0,50
< 0,55
< 0,60
< 0,65
ng WHO-TEQ/kg (air-)dried matter
(upper bound determination limit)

Figure 2 shows that most compound feeds are below 0.1 ng WHO-TEQ/kg (air-) dried matter, with a limited numbers of samples having a dioxin content up to 0.25 ng WHO-TEQ/kg.

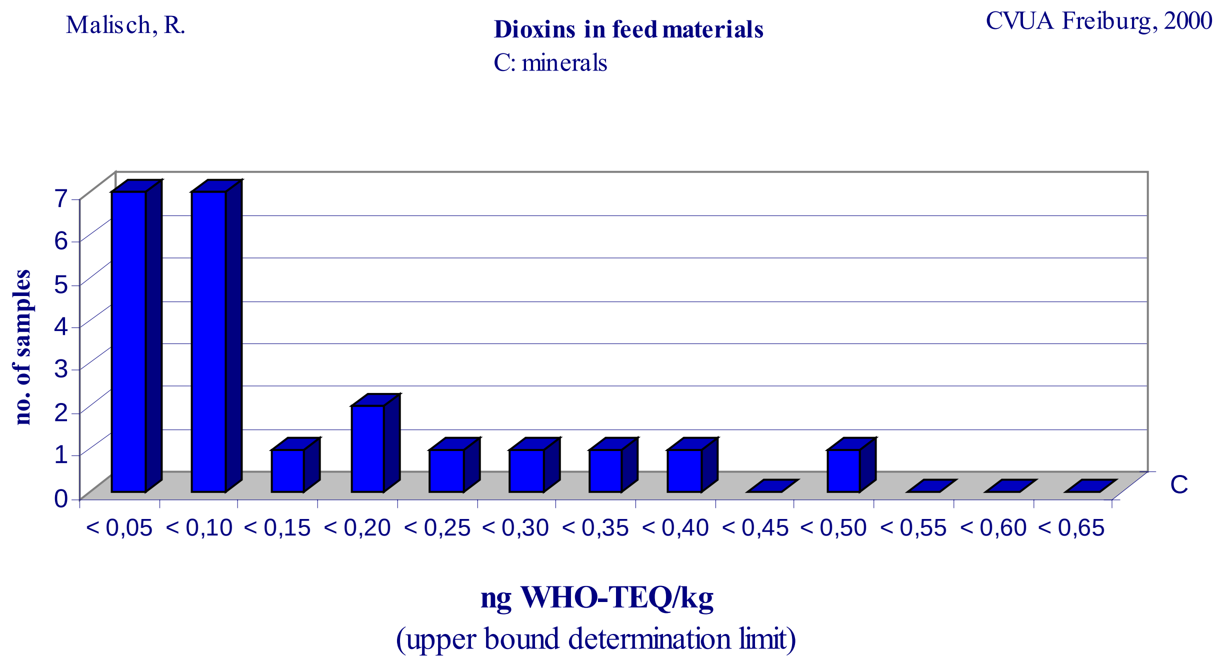
Figure 2



As a result, for feed materials of groups A2 to A4 or compound feeds a usual background contamination is in the range <0.1 to <0.3 ng WHO-TEQ/kg (air-dried) matter. Grass, hay and grass silage have a tendency to slightly higher dioxin levels. Almost all samples from the group A1 from rural and highly populated areas are below 0.5 ng WHO-TEQ/kg DM, however, more data from other areas in Europe would be necessary to support the overview.

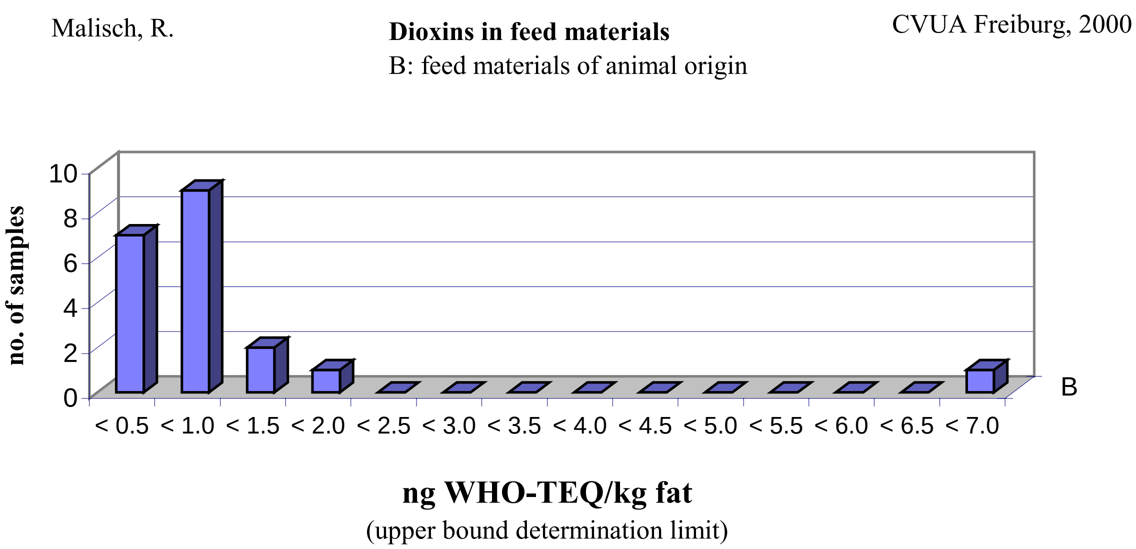
Figure 3 summarises the results of mineral feeds. Also here, the majority of samples have a dioxin content below 0.1 ng WHO-TEQ/kg. Most samples were analysed shortly after the first reports about the newly detected dioxin source in highly contaminated kaolinitic clay. At that time, some manufacturers of mineral feeds had different stocks of raw material. Mineral feeds from the market from the same producer could have a wide range of contamination. Thus, samples below 0.5 ng WHO-TEQ/kg were considered "not contaminated". However, it can be anticipated that after exclusion of the contaminated products, the frequency distribution in the range between 0.1 and 0.5 ng WHO-TEQ/kg would shift to lower dioxin levels.

Figure 3



The feed materials of animal origin including 19 fat samples and one milk substitute are shown in figure 4. Besides one sample, feed materials of animal origin had a dioxin contamination below 2ng WHO-TEQ/kg fat (upper bound determination level; only PCDDs/PCDFs included).

Figure 4



Most samples were below 1 ng WHO-TEQ/kg fat. One sample had a dioxin content of 6.64 ng WHO-TEQ/kg fat. The composition of the samples is not known as feed materials were sampled randomly at certain occasions, without having the composition of these. It cannot be excluded that the sample with a high dioxin content contained fish oil. For a broad overview, it is therefore necessary to include the contribution of fish oils, as well.

4.3.2. Estimation of background contamination of feed materials of vegetable origin, on the basis of food data

Considering that vegetables used as food and plants cultivated as feed materials are exposed to the same dioxin contamination conditions, the analysis of data available for food vegetables can be used to draw conclusions concerning feed materials of plant origin. Regarding the different contamination pathways, the differentiation of vegetables into the following four groups is useful (Malisch, 1998):

- Group 1: edible part growing underground reflecting the soil contamination (potatoes, carrots, onions, celeriac, beetroot)
- Group 2: edible part (fruit, tubers or others) growing on the ground reflecting basically the soil contamination (*e.g.* strawberries, zucchini (courgette), kohlrabi, celery, cauliflower, rhubarb)
- Group 3: leafy vegetables growing near to the ground reflecting the contamination of soil and air (*e.g.* lettuce, sugarloaf, endive, savoy cabage, leek, white cabbage, kale)
- Group 4: fruit growing distant to the ground reflecting the air contamination (*e.g.* apples, tomatoes, aubergines, paprika)

Table A2 summarises the updated results of all food samples reflecting background contamination. They were recalculated as ng WHO-TEQ/kg dry matter (upper bound determination limit; only PCDDs/PCDFs included) (Malisch, 2000b).

It can be concluded that:

- Generally, the background contamination of vegetables is in the range < 0.1 to < 0.3 ng WHO-TEQ/kg DM (upper bound determination level; PCDDs/PCDFs only).
- The only vegetable with a considerable soil-plant transfer of PCDDs/PCDFs is zucchini (Hülster, 1994; Hülster *et al*, 1994, Neumann *et al*, 1999). This is also obvious from the results of group 2. This observation stresses the fact that physiological specificities exist and that unexpected contamination cannot be excluded *a priori* from other vegetable materials not considered. In relation to its weight, kale has a very big surface with wax layers, which can absorb dioxins from the air much more efficiently than vegetable with a smaller surface. Thus, kale is a special kind of food, which illustrates the air-plant transfer.
- The dioxin content of potatoes for food use is in the range <0.1ng WHO-TEQ/kg dry matter. As there is a lack of data for potatoes by products used as feed materials, the dioxin content of these can be assumed to be similar to the dioxin content of potatoes for food use.

4.3.3. *Estimation of background contamination of feed materials of animal origin, on the basis of food data*

The following products of animal origin are used as feed materials:

- Fish oil, fish meal
- Animal fat, meat and bone meal
- Milk products

It can be assumed that the dioxin content in feed materials of animal origin is not different from the dioxin content of products of animal origin intended for human consumption. As there are many data available from the official food control, these data can be included to widen the overview. The compilation of EU dioxin exposure and Health data summarises the concentrations of dioxins in foods. For each sort of food, a wide range of dioxin concentrations is reported (European Commission, 1999a). Thus, the same questions as asked in the above chapter 4.1 must be answered for setting the background contamination in food of animal origin.

Additionally, it must be taken into account that the dioxin content in food and human samples has decreased considerably in the past 10 years. Thus, data from the beginning of the 90s cannot be used for setting the background contamination at the beginning of the new millennium.

The available information on the occurrence of dioxins in food of animal origin (animal fat, meat, milk (products)) is in the order of 1 ng I-TEQ/kg fat (SCOOP Task 3.2.5)

The dioxin content in fish is generally considerably higher. However, the levels vary considerably for two reasons. First, the dioxin contamination is different in different areas. Second, the level is dependent on the fat content of the fish which varies extremely between species (between 0.04 % for a pike and 40 % for an eel) and also between seasons. Because of the accumulation of PCDDs/PCDFs in fatty tissue, the extreme different fat amounts can cause extremely different dioxin levels when correlated to fresh weight or fat base.

5. TOTAL CONTAMINATION ESTIMATES OF TYPICAL DIETS AND IDENTIFICATION OF THE MAIN FEED MATERIALS CONTRIBUTING TO THE CONTAMINATION.

Table 11 summarises the dioxin contents of the main feed materials established by the SCAN on the basis of the available data submitted by Member States to the European Commission or published, or referring to maximum permitted levels according to current European legislation.

It includes the identified "low" and "high" levels and the mean level fixed by the SCAN, as basis to estimate the total dioxin content of each specific species diet. It must be underlined that the choice of the highest values was somewhat arbitrary due to the scarcity of data and limited information on the origin and conditions of analysis of the samples. This choice, made considering very severe if not the worst situations, aimed not to give realistic estimates but to evidence which feed materials were the most influential on the contamination of different types of diets.

Table 11 Dioxin contents of the basic feed materials evaluated by the SCAN from the available data (in ng WHO-TEQ/kg dry matter; with inclusion only of PCDDs/PCDFs).

	Dioxin levels in feed materials (ng WHO-TEQ/kg DM)		
Feed materials	**Low**	**Mean**	**High**
Roughages	**0.1**	**0.2**	**6.6**
Cereals and seeds (Legumes)	**0.01**	**0.1**	**0.4**
By-products of plant origin	**0.02**	**0.1**	**0.7**
Vegetable oil	**0.1**	**0.2**	**1.5**
Fish meal Pacific (Chile, Peru)	**0.02**	**0.14**	**0.25**
Fish meal Europe	**0.04**	**1.2**	**5.6**
Fish oil Pacific (Chile, Peru)	**0.16**	**0.61**	**2.6**
Fish oil Europe	**0.7**	**4.8**	**20**
Animal fat	**0.5**	**1**	**3.3**
Meat and bone meal	**0.1**	**0.2**	**0.5**
Milk replacers	**0.06**	**0.12**	**0.48**
Soil	**0.5**	**5**	**87**
Binders and anticaking agents	**0.1**	**0.2**	**0.5#**
Trace elements, macrominerals	**0.1**	**0.2**	**0.5#**
Premixes	**0.02**	**0.2**	**0.5#**

#: according to Commission Regulation n°2439/99 of 17 November 1999[9]

On the basis of the dioxin levels in feed materials taken from the available data and using the percentage of the different feed ingredients in the diets, total contamination estimates of typical diets have been calculated. They are summarised in Annex B. Each estimation in Annex B consists of two parts: the upper table presents the results of the contamination of all individual feed materials and of the total diet in ng WHO-TEQ/kg dry matter, the lower table the percentage of the contribution of each material to the dioxin contamination of the diet. For all diets, the derived values for low, mean and high contamination were applied. In addition, if fish meal or fish oil is used in the diet, the calculations are done separately

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assuming that fish meal/oil comes either from European waters or from Pacific waters.

It should be noted that the composition of the diets is expressed as percentage of an ingredient in the diet on a product basis and not on a dry matter basis, except for ruminants as in this case diet includes feed materials with a high water content (such as grass). For the other species, the different materials used are dry (*e.g.* cereals, fat or meal) and their dry matter content is almost equivalent to the product itself (their water content being ca 10%). Therefore this difference between product and dry matter was not considered significant and calculations were made using the diet composition data on a dry matter basis for ruminants and on a product basis for the other species. The total contamination levels are however expressed in ng WHO-TEQ / kg dry matter diet.

When available, the concentration of the dioxins directly measured in complete diets will be compared.

As the database for dioxin-like PCBs is scarce, low, mean and high values were established for dioxins only. The limited data available for different food materials of plant origin (which can be extrapolated to the corresponding feed materials) show that the WHO-TEQ values derived from the determination of dioxin-like PCBs are roughly in the same range as those determined for PCDDs/PCDFs. However, in fish and fish products, the contribution of dioxin-like PCBs might be 5 times higher than that of PCDDs/PCDFs. As a result, the relative contribution of the individual feed materials would change significantly. The WHO-TEQ values including PCDDs/PCDFs and dioxin-like PCBs would increase about 5 fold for fish and fish products, whereas for all other feed materials, the content would roughly be doubled.

5.1. Ruminants

All calculations on ruminants are based on the use of one concentrate, among the four identified in chapter 3 (table 2). Using a conservative approach, the Committee chose to use the levels of contamination identified for the Concentrate IV as it included fat of animal origin as well as fish meal, for the calculation of the contamination of the different ruminants diets, although more appropriate concentrates may be used in practice depending on the type of production and on the feed materials available. The calculated average contamination of this concentrate was the highest, if fishmeal from Europe is used, although in the same range as the others. The calculation of concentrates contamination is presented in Annex B, tables B1 and B2.

Calculations of the contribution of the individual feed materials to the different diets are presented in Annex B, tables B3 to B6 for dairy cattle, and B7 to B12 to beef cattle, which includes the particular case of veal calves (tables B11 and B12). Generally for all the different ruminant diets, the mean contamination is considered to reflect the usual background in the range of about 0.2ng WHO-TEQ/kg dry matter.

The relative dioxin contribution reflects the composition of the diet, which includes mainly roughage and concentrate with numerous variants in their respective rate. As roughage and concentrate IV are derived with 0.2

respectively 0.195 (which can even be rounded to 0.2) ng WHO-TEQ/kg dry matter, there is no effect on the dioxin content of the diet with variation of the composition. Changes of the composition of the concentrate show the influence of fish meal and animal fat: 5 % fish meal of European waters result in 31 % of the average dioxin content of concentrate IV, and 4 % animal fat in 21 %. Thus, the use of concentrates without these feed materials would lower the dioxin content of the diets with high portions of concentrate. However, the most important factor especially is roughage, as the comparison to low and high contaminated feed materials demonstrates. This is due to the level identified by the Committee in table 11 and leads to an increase of the diet contamination calculated in ng WHO-TEQ/kg dry matter by a factor of 10 to 30, depending on the rate of roughage in the diet composition. For example, in ruminant diet n°8 in table B9, the dioxin content increases from 0.2 ng WHO-TEQ/kg dm to 4.88 ng WHO-TEQ/kg dm, and 70% of the diet ingredients (roughage) contributes to 95% of the contamination.

In the case of veal calves, for the low and mean level calculation (see tables B11 & B12), the diet contamination results predominantly (84%) from milk replacer, constituting 90% of the daily ration. However the dioxin burden of milk replacer results from its lipid source and content. For the high level calculation, 10% roughage in the daily ration contributes to greater extent to the total dioxin intake than the milk replacer.

The presence of soil in the ingested components of the diet as well as direct consumption by animals on pasture can increase the total dioxin exposure of ruminants. However, it must be noted that the bioavailability of dioxins adsorbed on soil is lower than that of other dioxin sources. Of course, animals kept indoors, during winter for example, and more generally animals fed with diets including higher percentage of concentrates, have a lower risk of presence of soil and dioxin originating thereof. This applies in particular to the specific production of calves and "baby beef".

5.2. Pigs

Calculations on the diet contamination of piglets are presented in Annex B, tables B13 and B14, of pigs for fattening in tables B15 and B16 and of sows in tables B17 to B20.

Calculated on the basis of mean values of table 11, the level of contamination of all pig feeds is low, ranging from about 0.10 up to 0.23 ng WHO-TEQ/kg dry matter.

The derived maximum dioxin content for the average contamination (0.23 ng WHO-TEQ/kg dm) refers to piglets diets (see table B13). This is mainly due to the use of fish meal and animal fat in the piglets' diets. Diet n°2 as an example demonstrates the correlation. The addition of 8 % animal fat to a compound feed would result in a contribution to the dioxin content of 35 %. As well, the use of only 5 % of fish meal from European waters results in a dioxin contribution of 26 % of the whole diet, whereas the same amount of fishmeal from Pacific waters would give only 4 % of the total dioxin contribution. This is also seen for the other pigs' categories.

In the particular case of pig diet n°14, which includes 32% roughage and is intended for pregnant sows, the use of highly contaminated forage (instead of mean contaminated one) can cause up to ca 80% of the dioxin contamination of this fibrous diet. This can be explained by the figure retained by SCAN for the high level of contamination of roughage which is significantly higher than the mean level (respectively 6.6 and 0.2) and impacts consequently on the total contamination of this particular diet, causing a level for the maximum contamination of 2.5 ng WHO-TEQ/kg dry matter. In contrast to this, in other cases the high contamination does not exceed 0.8 g WHO-TEQ/kg dry matter. More generally, as to be expected, the use of highly contaminated materials multiplies the level of contamination of the diet by a factor of 4 to 5. In the case of pig diet n°14, the factor is even higher, as explained in the above paragraph.

The consumption of significant amounts of soil for outdoor bred animals can increase the exposure to dioxin, in particular for reproductive sows often bred outdoor. Although these animals are generally not used to produce meat, their progeny can be contaminated through suckling their mother until weaning.

Wild pig diets, although not described in this report, are characterised by the consumption of high amounts of soil, forage and roots. This may lead to higher dioxin intake in comparison with those of domestic pigs.

5.3. Poultry

Calculations on the poultry diets' contamination are presented in Annex B, tables B21 to B26.

The dioxin concentrations of poultry diets with low contaminated feed materials vary between 0.022 and 0.063 ng WHO-TEQ per kg. Under consideration of mean values of contamination (see table 11) dioxin concentrations of feedingstuffs vary between 0.114 and 0.194 ng WHO-TEQ per kg.

All diets contain less than 5 % of fish meal and up to 10 % of fat, with a sum of both ingredients being less than 10%, but the use of these two feed materials (5 % fish meal from Europe and 3 % of animal fat) contributes up to ca 50% of dioxin load on average (table B22, diet n° 1). This is also illustrated by table B26 with the diet n°7 for turkeys where fish meal and animal fat represent only 5% of the diet composition, but contribute to 36 % of the dioxin contamination.

As a result, higher proportions of fish meal and animal fat and higher contaminated feeds (see table 11) may significantly increase dioxin concentration of poultry feedingstuffs.

The evaluation of the mean dioxin content of poultry diets is in agreement with data from Malisch (2000b) who analysed 14 commercial poultry feedingstuffs from Germany and measured dioxin concentrations between 0.012 and 0.232 ng WHO TEQ/kg.

In addition to the exposure of animals to dioxins through their diets, in the case of free ranging animals, the soil intake may represent an additional source of contamination. Indeed, if between 2 and 10 g soil per layer and per day (see chapter 3.3.) is taken up, the additional dioxin intake varies between 0.001 and 0.87 ng WHO-TEQ per layer and per day considering the lowest and highest dioxin concentration of soil identified in table 11.

Assuming a daily feed intake of 120 g per hen and using mean values for the calculation of diet n°5 in table B23, the dioxin intake per day and per animal originating from the feed would be around 0.014 ng WHO-TEQ. Using also the mean contamination level of soil and a mean soil intake of 6g per day, the dioxin intake originating from soil would be 0.03 ng WHO-TEQ. So, for free ranging layers, on the basis of the sum of dioxin contribution from diet and soil, the soil could represent a significant part (around 70%) of the dioxin exposure of animals. Bioavailability is however lower for soil and should be considered for a proper assessment of its final impact on the contamination of food of poultry origin.

5.4. Rabbits

Calculations on the diet contamination of rabbits are presented in Annex B, tables B27 and B28. The dioxin contamination of rabbit feeds is between 0.13 and 0.17 ng WHO-TEQ/ kg dry matter and can be considered low.

There are no significant differences in the total contamination of the different kinds of feedingstuffs used for the two types of production (meat production and reproductive animals). This is explained by the relatively similar basic composition of the diets.

Table B28 shows that the contribution of the different feed materials to the overall contamination is consistent with their respective rate in the diet composition. However, the addition of 5% fat of animal origin can contribute to 30% of the diet contamination (diet n°2).

When considering high levels of contamination, roughage becomes preponderant as 20% inclusion in the diet brings ca 70% of the contamination. This is linked, as in the case of pig diet n°14 (see chapter 5.2), to the high level of roughage contamination retained by the Committee. It indicates that roughage, when highly contaminated, needs careful consideration.

Finally, apart from exposure to dioxins through their "classical" diet, rabbits raised in wooden cages or lactating does raised in cages fitted with wooden nest for their progeny can chew the surrounding wood material which, if treated with chlorinated preservative, can represent an additional source of contamination.

5.5. Fish

Calculations on the fish diet contamination are presented in Annex B, tables B29 and B30.

Clearly the dioxin contamination of the diet of farmed fish is relatively high, particularly for carnivorous species as their intake of fish meal and fish oil is quantitatively important. The origin of the fish meal and fish oil is also of great influence. When using European fish oil and fish meal, the diet contamination is ca 8 fold higher when compared to those based on fish meal and oil originating from the Pacific area (Chile, Peru). For omnivorous species, the differences are less dramatic because the percentage of fish meal and oil in their diet is considerably lower than for carnivorous species. This can be further applied to herbivorous fish species.

The use of fish oil of various origins is dependent on various factors such as import and export figures and market prices. In 1997 the net amount of European fish meal was ca. 30% against 70% of Pacific fish meal on a total usage of 1.4 million tonnes. However, due to El Niño, in 1998 the amount of European fish meal used has been much higher. Clearly these changes in use have a considerable impact on the TEQ levels in fish meal and fish oil. The contribution of other feed materials is only of some significance when combined with weakly contaminated South Pacific fish meal or fish oil (using low values).

In most fish oils and fish meals, dioxin-like PCBs determine ca 80% of the total TEQ, although variation (from 20% to 95%) may occur. This means that, when PCB TEQ are taken into account in addition to the dioxin TEQ, the mean total contamination level of an average product calculated in table B29 may increase from 1.8 to 9 ng WHO-TEQ/kg dry matter for feed materials (of fish origin) of European origin in the case of carnivorous species (for a high contaminated product, from 7.9 to 40 ng WHO-TEQ/kg dry matter). This is a considerable difference with the diet contamination calculated on the basis of dioxins only.

As shown in table B29, use of fish meal and oil with known low levels of contamination, like for instance some fish products originating from certain areas of the Pacific (Chile, Peru), can lower the global contamination. Although fish meal and fish oil still impact the most on the total diet contamination in comparison to other feed materials (see table B30), the diet contamination is divided by a factor of 8 (case of carnivorous species).

If the use of less contaminated feed materials of fish origin has a positive impact on the whole diet contamination, it is rather limited; leading to a decrease from 98% to ca 89% of the dioxin contribution in the case of carnivorous species. Alternative feed materials to replace fish meal and oil in fish diet could contribute to lower this impact, provided these alternatives are less contaminated. There is indeed a tendency to reduce the use of fish meal and fish oil in farmed fish diets through the utilisation of plant seed oils such as soybean meal and, to a lesser extent single cell proteins. However one must be aware that nutritional constraints exist that limit the exercise. Finally, in order to overcome the contamination of fish oil known to be heavily contaminated (case of fish oil of European origin), use of purification/decontamination techniques, like for example distillation methods, are currently envisaged.

5.6. Identification of the main contributors to diets contamination

Considering the best situation, *i.e.* calculating diet burden using the low levels established by the SCAN for all feed materials, it appears that, whatever animal species is considered, all different diets exhibit low contamination levels below 0.1 ng/kg diet, except for carnivorous fish fed fish oil and fish meal from European origin for which this value is around 0.2 ng/kg diet.

On the basis of the mean values retained by the SCAN that reflect the average situation, whatever animal species is considered, the whole dioxin burden is comprised between 0.1 and 0.3 ng/kg diet, except for carnivorous fish that receive fish meal and fish oil of European origin. In that case dioxin contamination reaches 1.8 ng/kg diet.

Using the high and somewhat arbitrary and overestimating dioxin concentrations retained (see above, chapter 5.), the whole contamination is over 0.5 ng/kg diet, the ruminants and fish being the most exposed with a dioxin burden far over 1 ng/kg diet. One exception is that of the omnivorous and carnivorous fish receiving fish oil and fish meal originating from the South Pacific area where the value remains below 0.9 ng/kg diet.

Considering the rate of inclusion of feed materials combined with their impact (in percentage) on the total contamination of the diets, feed materials of fish origin (of European origin) and animal fat represent the major contributors to diets contamination. For instance, low quantities (5% to 8%) of these ingredients lead to around a third of the diet contamination (in pigs or poultry). When these feed materials are used together, their contribution can represent more than 50% of the contamination.

In the case of diets made of one or two predominant feed materials (like for ruminants or for fishes), the diet contamination is mainly the result of the proportion of these materials in the diet. For this reason, roughage and feed materials of fish origin are the respective main contributors to diets of ruminants and fishes.

As farmed fish combines an important consumption of feed materials of fish origin (up to 75% in the diet of carnivorous species) with a high level of contamination of these feed materials, it is the food producing animal most exposed to dioxins.

A special mention should be made on the contribution of soil as a significant part of the diet of certain animals, *i.e.* grazing ruminants and free-range animals. However its importance in terms of dioxin availability for the animals cannot be evaluated on the basis of the present knowledge.

6. Carry over of dioxins from feed to food

6.1. General findings

Generally, PCDDs/PCDFs are chemically stable and poorly water-soluble. As a result of their persistence and lipophilic properties, they are slowly degraded in the environment and are bioaccumulated within the food chain. However, depending on the degree and the position of chlorination, the individual PCDDs and PCDFs congeners possess different physical and chemical properties, which determine their environmental behaviour. The carry-over of dioxins from feed to food depends on different factors:

- Degree and position of chlorination of PCDDs/PCDFs: In the food chain, only the 17 congeners with 2,3,7,8-substitution are bioaccumulated (tetra- to octachlorinated PCDDs/PCDFs). These congeners are more stable against the main enzymes involved in the metabolism of aromatic compounds in animals. Even within the group of the 17 congeners with 2,3,7,8-substitution, a wide range of different transfer rates can be observed. Whereas 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD and 2,3,4,7,8-PeCDF have a relatively high transfer rate from feed to cow's milk, 2,3,7,8-TCDF, OCDD and OCDF have a low transfer rate. Other congeners are between these extremes.

- Animal species: whereas in mammals predominantly 2,3,7,8-substituted congeners are found, fish can also contain non-2,3,7,8-substituted congeners. Birds and eggs normally contain mainly 2,3,7,8-substituted congeners, but in case of an actual contamination, also non-2,3,7,8-substituted congeners can be determined.

- Kind of the matrix: soil or fly ash adsorb dioxins much stronger than grass or other digestible feedingstuffs, which reduces their bioavailability.

At steady-state, the amount of dioxins absorbed is equal to the amount of dioxins which are eliminated. The time to reach steady state is quite long (in the range of months). The half-life of individual congeners varies and can be assumed for excretion in milk for TCDD with about 40 days and for OCDD with about 80 days.

6.2. Calculation of transfer factors

The numerous ways of expressing contaminant carry-over found in the literature lead to considerable difficulties in interpreting different studies, and some standardisation is necessary. Therefore, the specific definitions of different authors such as bioconcentration factor, carry-over ratio, transfer efficiency or transfer rates have to be used.

Factors for the transfer from feed to cow's milk can be calculated according to the following formula:

$$transfer\ \ factor = \frac{c_{mf}}{c_f} * \frac{p_{mf}}{f}$$

with

c_{mf} = concentration in milk fat (pg/g),

c_f = concentration in feed (pg/g),

p_{mf} = daily production of milk fat (g),

f = daily amount of feed intake (g)

Transfer factors (TF) are dimensionless, whereas transfer rates (TR, also called carry-over ratios, COR) can be calculated also as percentage of the daily dose that is transferred to milk fat at steady state (TR = TF * 100).

6.3. Results from relevant investigations

The transfer from grass to milk (see table 12) was studied in detail by McLachlan *et al.* (1990). There, the "PCDDs/PCDFs fluxes out of the cow into milk" were calculated as "% input" and are equal to "transfer rates". In a study of Schuler *et al* (1997b) with feeding of grass over a period of two years with 4 sampling dates, for example a range between 0.06 and 0.7 was observed for 2,3,7,8-TCDD, with an average of 0.3.

Fürst *et al*. (1993b) investigated PCDDs/PCDFs levels in cow's milk in relation to their levels in grass and soil. The results indicated that the pathway air grass cow is more important than the pathway soil grass cow. Moreover, it became apparent that the carry-over for PCDDs/PCDFs between grass and cow's milk differs significantly depending on congeners. While 2,3,7,8-TCDD showed the highest carry-over, OCDD was accumulated less by a factor of almost 40 compared to 2,3,7,8 TCDD. The relative ratio of the factors determined for each congener concerned was very similar irrespective of the dioxin levels in the grass at the different sampling sites.

After administration of a single dose of contaminated fly ash to two cows, the bioavailability (as percentage) was low: 0.17 % resp. 1.21 % for TCDD (Slob *et al*., 1995). However, the bioavailability was comparable to the results for grass of McLachlan *et al* (1990) and Schuler *et al* (1997b), when grass of the neighbourhood of a large Municipal Solid Waste Incinerator was fed to cows.

Table 12 Transfer factors for PCDDs/PCDFs from grass or citrus pulp to milk (reported in literature)

		McLachlan *et al.* (1990)	Slob *et al.* (1995)		Schuler *et al.* (1997b)					Malisch (2000)
			loc. A	loc. B	Sep 94	May 95	June 95	Oct 95	mean	
I-TEQ		0.20								0.40
WHO-TEQ										0.44
2,3,7,8-	TCDD	0.35	0.15	0.15	0.1	0.06	0.7	0.4	0.3	0.58
1,2,3,7,8-	PeCDD	0.33	0.11	0.10	0.08	0.2	0.3	0.2	0.2	0.49
1,2,3,4,7,8-	HxCDD	0.17	0.057	0.055	0.05	0.06	0.07	0.1	0.08	
1,2,3,6,7,8-	HxCDD	0.14	0.062	0.065						
1,2,3,7,8,9-	HxCDD	0.18	0.031	0.032						
1,2,3,4,6,7,8-	HpCDD	0.03	0.0062	0.0062	nd	0.03	nd	0.01	0.02	
	OCDD	0.04	0.0012	0.0008	0.004	0.02	0.001	0.009	0.008	
2,3,7,8-	TCDF	0.07	0.0087	0.0078	0.01	0.02	0.04	0.02	0.02	0.028
1,2,3,7,8-	PeCDF	0.06	0.0040	0.0053	0.02	0.04	0.04	0.05	0.04	0.038
2,3,4,7,8-	PeCDF	0.25	0.12	0.12	nd	0.7	nd	0.2	0.5	0.58
1,2,3,4,7,8-	HxCDF	0.19	0.043	0.043	0.05	0.1	0.1	0.04	0.07	0.33
1,2,3,6,7,8-	HxCDF	0.16	0.036	0.035						0.30
2,3,4,6,7,8-	HxCDF	0.14	0.042	0.042						0.19
1,2,3,7,8,9-	HxCDF									
1,2,3,4,6,7,8-	HpCDF	0.03	0.0039	0.0037	0.004	0.01	0.02	0.01	0.01	0.031
1,2,3,4,7,8,9-	HpCDF	0.08	0.0037	0.0064						0.042
	OCDF	0.01	0.00	0.00	0.01	0.009	0.02	0.01	0.01	0.004

The same bioavailability as reported for grass was observed by Malisch (2000) for the transfer from contaminated citrus pulp to milk. Here, the use of highly contaminated lime was the source of the dioxin contamination of the citrus pulp. Lime is added to the wet peel for neutralization and constitutes about 2 % of the dried citrus pulp. Lime is dissolved in acid conditions easily, thus PCDDs/PCDFs adsorbed on lime are much more bioavailable than *e.g.* PCDDs/PCDFs adsorbed on soil or fly ash. It can be assumed that lime is dissolved completely during the neutralization step of the citrus pulp and that PCDDs/PCDFs are adsorbed on the citrus pulp. Thus, the bioavailability of PCDDs/PCDFs in the contaminated citrus pulp is more similar to grass with deposition of PCDDs/PCDFs from air. It was concluded that the absolute numbers of the transfer factors, at least of the predominant congeners, were in line with the literature [Olling *et al* (1991), Jilg and Müller (1994), Tuinstra *et al* (1992) and Traag *et al* (1999)], and that the general tendency (highest transfer rates for 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD and 2,3,4,7,8-PeCDF; low transfer rates for higher chlorinated PCDDs/PCDFs and 2,3,7,8-TCDF) was met.

A transfer rate for the I-TEQ-value and the WHO-TEQ-value (based on WHO TEFs) can be calculated only from specific experiments because these rates depend strongly on the congener pattern. These calculated values must be considered as purely indicative and cannot be generalized.

Concerning the PCDD/PCDF transfer from feed to meat, two studies revealed results that are somewhat contradictory. While Ruoff (1995) found a highly variable distribution of individual congeners between different tissues of the same animal, a German-French joint programme, where food samples from different regions from the upper Rhine river valley were compared, demonstrated, as to be expected, that the dioxin levels of different types of meat, but not liver, are nearly the same when expressed on fat basis.

From a scientific point of view, comprehensive studies to calculate the transfer of PCDDs/PCDFs from feed to meat would be extremely difficult and could face severe problems when compared to studies carried out to determine the transfer of these compounds to milk or eggs. Different kind of animals (cows, pigs or poultry) would have to be studied to take into account metabolic specificities. As it may be anticipated that steady state is reached after 100 to 200 days, a large and statistically relevant number of animals would have to be slaughtered, and different tissues, *i.e.* different types of muscles and fats, liver and kidneys, would have to be analysed to highlight distribution specificities.

Previous studies have shown that free foraging chickens can take up PCDDs/PCDFs from soil and rapidly transfer them into eggs. Moreover, these studies indicated that the concentrations and congener profiles of PCDDs/PCDFs in eggs of chickens appeared to be related to the soil on which they were raised. Thus, the official food control usually differentiates dioxin levels in eggs depending on the type of housing, *i.e.* eggs from caged chicken, foraging chicken, or from chicken kept on ground (Fürst *et al*, 1993a). The transfer of PCDDs/PCDFs from soil into eggs of foraging chicken was studied by Stephens *et al*. (1990 and 1995) and Schuler *et al* (1997a).

Table 13 summarises the “transfer efficiencies” (calculated in g dry weight/g lipids) proposed by the latter.

It appears that the transfer rates decreased with increasing chlorination of the congeners over more than one order of magnitude from the PeCDD/PeCDF to OCDD/OCDF. The relatively moderate transfer efficiency observed for 2,3,7,8-TCDD/TCDF could not be explained.

Table 13 Transfer efficiencies "soil to eggs" (calculated in g dry weight/g lipids):

PCDDs/PCDFs		Transfer
2,3,7,8-	TCDD	1.2
1,2,3,7,8-	PeCDD	2.4
1,2,3,4,7,8-	HxCDD	1.5
1,2,3,6,7,8-	HxCDD	1.6
1,2,3,7,8,9-	HxCDD	0.8
1,2,3,4,6,7,8-	HpCDD	0.4
	OCDD	0.1
2,3,7,8-	TCDF	3.3
1,2,3,7,8-	PeCDF	4.4
2,3,4,7,8-	PeCDF	0.8
1,2,3,4,7,8-	HxCDF	0.9
1,2,3,6,7,8-	HxCDF	1.0
2,3,4,6,7,8-	HxCDF	0.6
1,2,3,7,8,9-	HxCDF	0.1
1,2,3,4,6,7,8-	HpCDF	0.2
1,2,3,4,7,8,9-	HpCDF	0.1
	OCDF	0,1

Little is known about transfer of dioxins from feed to fish. Some biota/sediment studies were carried out by Loonen *et al.* (1994), but that study does not give information on dioxin transfer from feed to biota. As the dioxin and furan pattern in average fish oil and fish meal contains in particular congeners which are readily bioavailable such as 2,3,7,8-TCDD and 2,3,7,8-TCDF, it is expected that a considerable amount of dioxins and furans will be transferred from fish oil and fish meal to animals with a diet containing fish meal and/or fish oil.

A study on PCB transfer has been carried out by de Boer and Pieters (1991). In that study, it was shown that the transfer rates of PCBs from feed to eel were ca 80% for the PCBs 52, 101, 153 and 180. These results corresponded with those reported by Lieb *et al.* (1974) who found transfer rates of 68% for rainbow trout. This means that the major part of the PCBs is being transferred from the feed to the fish. Assuming a similar behaviour of ortho and non-ortho chlorobiphenyls and considering that PCB can determine ca 80% of the total TEQ, at least 60% of the total dioxin + PCB TEQ in fish feed is likely to be transferred to fish.

6.4. Use of TEQ values for carry-over calculation

The dioxin transfer from feed to food is essentially congener-specific. Calculated factors may vary considerably depending also on the matrix ingested (*e.g.* soil, grass or fat) and the animal species. Therefore, taking into account the very different congener patterns which are found in different samples, the determination of an unique transfer rate from feed to food is not possible. Only in case of a consistent and well-defined congener pattern, overall transfer rates may be used. As a result, only a few publications mention a transfer factor calculated from the results of their specific experimental conditions. As an example, the transfer rate from grass to milk calculated on I-TEQ-base was in the range between 0.08 and 0.27 (Schuler *et al*, 1997b). For citrus pulp, Malisch (2000a) found a transfer factor of 0.40 on I-TEQ-base and of 0.44 on WHO-TEQ-base. However these very limited data do not allow to propose a range of values for these factors. As a consequence, it is not scientifically correct to use compiled dioxin data in feedingstuff based only on the TEQ-content, for calculation of a possible transfer from feed to food.

7. ANIMAL HEALTH ASPECTS

A considerable amount of work on risk evaluation for the humans has been published covering the many aspects of dioxin toxicity. In contrast, very little data exist concerning the toxicity of dioxins for non-laboratory animals and farm animals in particular. Until recently the toxic episodes described were related to the intake of accidentally contaminated feedingstuffs, but in these few cases no correlation has been drawn between levels of real exposure of the animals (both for intensity and duration) and the severity of symptoms of disturbances suffered by the animals.

The alert that started the recent dioxin crisis in Belgium arose from an observation by breeders and egg producers of decreased laying (10 to 30%) and hatchability of hen's eggs, as well as intoxication signs (neurological syndromes) in the surviving chickens (Federal Ministry of Agriculture - Belgium, 2000). These eggs were laid by animals exposed to feedingstuffs that were later confirmed to be contaminated by dioxins originating from PCB polluted animal fat. The highest dioxin concentration measured in hen feedingstuffs was 781 ng I-TEQ/kg dry matter, which corresponds to an oral exposure of the birds of about 30 ng /kg live weight. The second episode of feedingstuff contamination that occurred in Austria in 1999, due to the use of contaminated kaolinitic clay as a binder/anti-caking agent additive, did not give rise to toxic outbreaks in pigs and poultry. It must be noted that the feedingstuff dioxin contents were in a range of 4.8 to 6.2 ng I-TEQ/kg dry matter, that corresponds to an exposure of the animals of about 150 fold lower than during the Belgian event.

Considering worse case scenario using upper levels of contamination, the contamination of the diet would reach 8 ng WHO-TEQ/kg diet (according to the highest value obtained in the calculation for fishes in table B29). On the basis of a daily feed consumption of 2% of the body weight, the exposure of the animals would be 0.006 and 0.16 ng/kg/day b.w. respectively, figures which are considerably lower than the exposure level that created toxic outbreaks in chickens reproduction.

Therefore, although no data is available on the impact of the diets, when contaminated at the levels identified by SCAN, it may be anticipated that no adverse effect would occur in mammals, birds and fish, provided that they are not challenged by severe accidental contaminations.

8. CONCLUSION

For humans, it is well known that more than 90% of the daily dioxin intake comes from food. In the same way it can be assumed that the animal dioxin body burden derives mainly from feeding. Therefore feedingstuffs, and in some cases soil, are of special concern as potential sources of dioxins.

Considering the sources of the contamination of feed materials by dioxins, PCBs and dioxin-like PCBs, the following points must be stressed:

- The ubiquitous environmental distribution of these compounds causes a background contamination affecting all terrestrial plants directly grazed (pastures) or used as raw materials for animal feeding as well as the aquatic feed chain. This is also true for the soil that might contaminate feed materials, or which can be directly ingested by the animals.
- In addition to background contamination, direct accidental pollution of feed materials may occur due to:
  - the localised discharge of dioxins from industrial activities including materials containing or generating such compounds, but also from polluted waste water,
  - the contamination of feed materials during their production (especially the use of contaminated chemical or chemical by-products), processing and transportation ,
  - illegal practices or management failures during feed production
- Due to their physical (lipophilic nature) and chemical (stability) properties, these compounds accumulate in animal tissues and are also transferred to animal products (milk, eggs).

8.1. Identification of contaminated feed materials

Until the recent dioxin crises, only a very limited number of data was available for dioxin contamination of most feed materials due to the lack of awareness of the importance of feedingstuffs for the dioxin contamination of food of animal origin, but also for reasons of limited technical and financial resources.

The lack of sensitivity of a number of analytical techniques used, namely in terms of upper bound limits of detection and determination, makes the interpretation of the results difficult, with the risk of an overestimation of background levels.

The frequency distribution of dioxin levels in feed materials shows that the average background contamination is in the range of 0.1 to 0.3 ng WHO-TEQ /kg DM (upper bound limit of determination) for feed materials of vegetal origin and minerals, and 0.1 to 1 ng WHO-TEQ/kg fat for animal fat (fish oil excluded).

The high variability of the results may reflect local contamination conditions that most of the time cannot be clearly differentiated between background and accidental contaminations. This is especially true for grass and forages dioxin aerial contamination. However, on the basis of data supplied by Member States and open literature published data, the SCAN has established, considering worst case assumptions, lower, mean and upper levels of dioxins.

The ranking of the contamination levels indicates that:

(a) If fish oil and fish meal are used for diets, they can contribute considerably to the dioxin contamination of animal diets, even if their percentage in the diet composition is low. However, the origin of the fish is decisive, as fish oil and fish meal from Europe is much more contaminated than the corresponding products from South Pacific (Chile, Peru)

(b) Animal fats can also contribute to the overall contamination due to the lipophilic properties of dioxins and their bioaccumulation in the food/feed chain.

(c) All the other and quantitatively major feed materials of plant (roughages, cereals, proteinaceous sources) and of animal (milk by-products and meat and bone meal) origin normally contain mean concentrations around or below 0.2 ng WHO-TEQ/kg dry matter. Amongst these remaining feed materials, roughages present very wide concentration ranges depending on anthropomorphic genesis conditions and aerial dispersion of dioxins, which explains the upper values observed.

(d) Finally soil shows an even wider range of contamination, but its contribution is limited to the consumption of the fraction adhering to feed materials into contact, and to free range animal productions. Moreover, the bioavailability of the dioxins adsorbed onto the soil is low.

(e) Considering the rate of inclusion of feed materials combined with their impact (in percentage) on the total contamination of the diets, feed materials of fish origin (of European origin) and animal fat represent the major contributors to diets contamination. The impact is increased when, in addition, such feed materials represent the main quantitative component of the diets, like for instance for carnivorous fishes.

The contribution of dioxin-like PCBs to the contamination of feed materials is not sufficiently investigated to be taken into account into the SCAN assessment of the diet burden. However, the limited data available indicate a contribution similar to dioxins in all the feed materials, except for fish meal and fish oil where dioxin-like PCBs would increase the total TEQ value about 5 fold. This worsens the situation and should be taken into consideration for purposes of risk management.

8.2. Contribution to the contamination of food of animal origin

Depending on the degree and on the position of chlorination, the individual PCDDs and PCDFs show very different transfer rates. As a consequence, it is not scientifically correct to calculate transfer from feedingstuffs to products of animal animal origin on a TEQ basis only. The transfer can be calculated only on the basis of the congener profiles.

8.3. Impact on animal health

The only data available that allow us to relate farm animal exposure to toxic outbreaks indicate that no adverse effect would occur in mammals, birds and fish if they are not challenged by severe accidental contaminations.

8.4. Need for data

There is a clear lack of (consistent) data in the feed sector. Most data have been issued after the different dioxin crises and the information they provide is poor in terms of sampling and geographical distribution. In addition, the data available refer mainly (when not only) to dioxins. Data on dioxin-like PCBs are also needed for the evaluation of the diets contamination, as they can significantly (multiplication by a factor of 5 in the case of feed materials of fish origin, according to the available data on fish contamination) impact on the total TEQ calculation.

9. RECOMMENDATIONS

9.1. The reduction of human exposure to dioxins related to food consumption is important to ensure consumer protection. Food of animal origin is a predominant source of exposure of consumers to dioxins. As food contamination is directly related to feed contamination, consistent cross-sectorial actions must be taken to reduce final dioxin impact on human health.

9.2. An integrated approach should be followed to reduce the dioxin incidence all along the food chain, *i.e.* from feed materials to food producing animals then to humans. Taking measures on feed materials and feedingstuffs is thus an important step to reduce the dioxin uptake by human.

9.3. As far as feed materials are concerned,

– Emphasis should be put on reducing the impact of the most contaminated feed materials, *e.g.* fish meal and fish oil from Europe, on overall diet contamination. This could be achieved by substituting the most contaminated by lesser contaminated sources, by reducing their intrinsic contamination or by using non (less) contaminated alternatives, continuing to meet the animal nutrient requirements.

– Any material (recycled products, raw materials, ingredients) used in the manufacturing of feed materials should be guaranteed for quality and safety so that it would not become a source of contamination.

– Good manufacturing practices as well as use of Hazard Analysis and Critical Control Point (HACCP) principles should be introduced / continued at feed industry level to control the dioxin contamination along the different steps of the manufacture of feed.

– Efforts should be made to reduce dioxins contamination of feed resources at farm level (Good agricultural practices) and controlling local conditions of livestock production (*e.g.* direct environment of dairy farms, free range animal production), in particular in areas where soil contamination is elevated.

9.4. In addition, considering the impact of the environmental pollution on the contamination of feed materials, measures implemented with the aim to reduce the general dioxin burden should be actively continued.

9.5. There is a need for data on dioxins, but also dioxin-like PCBs and PCBs contamination of the widest range of feed materials and feedingstuffs in order to determine background levels so as to identify unknown contamination sources. A particular effort should be put into obtaining more data for feed materials for which a wide range of contamination is reported.

9.6. Scientific cooperation should be promoted in order to collect and collate information available in the different Member States at the EU level.

9.7. Monitoring programs could be organised at European level in order to widen the current limited geographical basis of the information on feed materials contamination.

9.8. Regarding the huge amounts of feedingstuffs being produced and sold world wide, feed materials imported from third countries should be checked for their dioxin content with the aim to avoid additional dioxin burden on feedingstuffs.

9.9. Data should be obtained from fully identified samples (contaminated or not) and techniques. In particular, two important aspects: indications or checks, whether samples were possibly contaminated, and the definition of the limit of determination have to be considered and reported to make data useful and useable. The concept of upper bound determination limits should therefore be implemented.

9.10. Analytical means should be developed and appropriate analytical requirements adopted according to the aim of the analysis carried out. For instance, in the case of checks of dioxins levels for control purposes, the analytical limits of determination should be in the range of one fifth of the regulatory limits whereas for control of time trends of background contamination, the limit of determination should be clearly below the mean of the present background ranges for the different matrices.

9.11. Emphasis should be put also on quality and qualifications of laboratories involved in monitoring programs and control activities of or for feed producers. Interlaboratory calibration studies should be promoted, using reference materials with certified dioxin and dioxin-like PCBs contents which should be made available. With this regard, the Committee welcomes the recent initiative of the European Commission (2000/C 290/05)[10] inviting for submission of proposals to support the development of Certified Reference Materials, in particular in the field of environmental contaminants in food and animal feed (topic IV.20) and specifically for PCDDs, PCDFs and PCBs in food and feed products. Such actions should be promoted.

9.12. Basic research is needed on studying the carry-over and establishing pertinent transfer factors for dioxin-like PCBs congeners from soil and feed to animals tissues and products (milk, eggs).

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[10] OJ n° C 290 of 13.10.2000, p. 4

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11. Annex A: Data available

11.1. Table A1

Dioxin results of feed materials and feedingstuffs samples (WHO-TEQ as upper bound determination limit of PCDDs/PCDFs determination) (Malisch, 2000)

	ng I-TEQ/ kg dry matter	ng WHO-TEQ/ kg dry matter	ng I-TEQ/ kg fat	ng WHO-TEQ/ kg fat
A1: forages and conservates				
Samples without hints on sources for a possible dioxin contamination				
No. of samples	**67**	**67**		
Mean	0.173	0.187		
Median	0.145	0.148		
Minimum	0.030	0.037		
Maximum	0.500	0.509		
90 %-percentile	0.311	0.336		
95 %-percentile	0.374	0.380		
Contaminated samples				
No. of samples	**6**	**6**		
Mean	5.900	6.604		
Median	4.082	4.146		
Minimum	0.832	0.835		
Maximum	20.155	24.073		
90 %-percentile	12.677	14.654		
95 %-percentile	16.416	19.364		
A2: tubers and roots				
No. of samples	**2**	**2**		
Mean	0.021	0.036		
Minimum	0.016	0.030		
Maximum	0.026	0.043		
A3: cereals and seeds				
No. of samples	**8**	**8**		
Mean	0.035	0.037		
Median	0.008	0.010		
Minimum	0.005	0.007		
Maximum	0.182	0.184		
90 %-percentile	0.091	0.092		
95 %-percentile	0.137	0.138		
A4: by-products of plant origin				
Samples without hints on sources for a possible dioxin contamination				
No. of samples	**19**	**19**		
Mean	0.064	0.072		
Median	0.055	0.062		
Minimum	0.012	0.016		
Maximum	0.122	0.132		
90 %-percentile	0.120	0.124		
95 %-percentile	0.122	0.132		
Contaminated samples				
no. of samples	**18**	**18**		
Mean	7.317	7.925		
Median	7.295	7.886		
Minimum	4.635	5.131		
Maximum	10.145	11.208		
90 %-percentile	9.394	10.093		
95 %-percentile	9.681	10.290		

	ng I-TEQ/ kg dry matter	ng WHO-TEQ/ kg dry matter	ng I-TEQ/ kg fat	ng WHO-TEQ/ kg fat

Summary: all samples of group A without specific contamination

No. of samples	**96**	**96**		
Mean	0.137	0.150		
Median	0.110	0.121		
Minimum	0.005	0.007		
Maximum	0.500	0.509		

B1: feeds of animal origin - without pure fat or oil

no. of samples	**3**	**3**		**1**
Mean	0.100	0.108		0.34
Minimum	0.055	0.061		0.34
Maximum	0.145	0.160		0.34

B2: pure fat or oil (definitely or probably of animal origin)

No. of samples			**19**	**19**
Mean			0.93	1.04
Median			0.63	0.68
Minimum			0.24	0.26
Maximum			5.68	6.64
90 %-percentile			1.31	1.42
95 %-percentile			2.14	2.42

C: mineral feeds

Samples without hints on sources for a possible dioxin contamination				
No. of samples	**22**	**22**		
Mean	0.113	0.126		
Median	0.064	0.071		
Minimum	0.013	0.015		
Maximum	0.454	0.483		
90 %-percentile	0.253	0.298		
95 %-percentile	0.330	0.355		
Contaminated				
no. of samples	**30**	**30**		
Mean	39.004	45.816		
Median	11.183	12.359		
Minimum	0.371	0.414		
Maximum	415.983	478.646		
90 %-percentile	64.806	73.831		
95 %-percentile	188.071	236.107		

D: compound feeds

Samples without hints on sources for a possible dioxin contamination				
No. of samples	**33**	**33**		
Mean	0.061	0.068		
Median	0.051	0.052		
Minimum	0.008	0.011		
Maximum	0.232	0.246		
90 %-percentile	0.127	0.136		
95 %-percentile	0.138	0.155		
Contaminated				
No. of samples	**18**	**18**		
Mean	1.726	1.851		
Median	1.656	1.750		
Minimum	0.498	0.479		
Maximum	8.566	9.546		
90 %-percentile	2.045	2.133		
95 %-percentile	3.232	3.449		

11.2. Table A2

PCDD/PCDF-content of vegetable food (in ng WHO-TEQ/kg dry weight) (Malisch, 2000)

	Group 1	group 1: potatoes only	group 2 all samples besides zucchini	Group 2: Zucchini only	group 3: all samples besides kale	group 3: kale only	group 4	all samples
Median	0.0683	0.0424	0.0395	0.2670	0.1354	0.2754	0.0777	0.1310
Mean	0.1046	0.0571	0.0787	0.4335	0.1906	0.3601	0.1484	0.2008
Minimum	0.0143	0.0154	0.0170	0.1860	0.0235	0.0871	0.0194	0.0143
90 % percentile	0.2264	0.1089	0.1652	0.8696	0.3335	0.7766	0.3104	
95 % percentile	0.3132	0.1494	0.2023	0.9559	0.4233	0.7802	0.4545	
Maximum	0.4197	0.1899	0.2458	1.0051	0.9720	0.7806	0.7523	1.0051
no. of samples	25	8	12	13	59	14	15	138

11.3. Table A3

Dioxin levels in fodder

Feed	**Number of samples**	**I-TEQ (ng/kg dry matter)**	**WHO-TEQ (ng /kg dry matter)**	**References**
Grass	11	0.8	-	European Commission, 1999a
	29	1.6	-	
Rye grass	Not given	2.1	-	
	Not given	1.3	-	
Kale	Not given	1.0	-	
	15	0.13	-	
	10	1.35	-	
	5	0.48	-	
Silages	63	0.20 (0.12-0.5)	-	
Forages	67	0.17 (0.03-0.5)	0.2 (0.04-0.51)	Malisch, 2000

11.4. Table A4

Dioxin levels in cereals and seeds

Feed	**Number of samples**	**I-TEQ (ng /kg product or per kg dry matter)**	**WHO-TEQ (ng /kg product or per kg dry matter)**	**References**
Barley	5	0.084 (upper bound) 0.030 (lower bound)		German feed mills 1999
	2	0.16 (DM)		Schöppe *et al.* 1997
	1	0.009 (DM)	0.012 (DM)	Malisch, 2000
	NG	0.018 – 0.088		European Commission, 1999b
	Raw	0.071 (DM)		Kube and Schöppe 1998
	After sieving	0.090 (DM)		Kube and Schöppe 1998
	Barley dust	0.330 (DM)		Kube and Schöppe 1998
	After cleaning	0.047 (DM)		Kube and Schöppe 1998
	NG		0.088	Austrian data 2000
Corn	4	0.080 (upper bound) 0.027 (lower bound)		German feed mills 1999
	NG	0.005 - 0.150		European Commission, 1999b
	1	0.007 (DM)	0.009 (DM)	Malisch, 2000
	1 after drying	0.182 (DM)	0.184 (DM)	Malisch, 2000
	6		0.040 – 0.150	Austrian data 2000

Feed	Number of samples	I-TEQ (ng /kg product or per kg dry matter)	WHO-TEQ (ng /kg product or per kg dry matter)	References
Oats	NG	0.150 (DM)		Schöppe and Kube-Schwickardi, 1996
	NG		0.082	Austrian data 2000
Rye	6	0.093 (upper bound) 0.045 (lower bound)		German feed mills 1999
	2	0.22 (DM)		Schöppe and Kube-Schwickardi, 1996
	NG		0.084	Austrian data 2000
Triticale	NG	0.068 (DM)		Schöppe and Kube-Schwickardi, 1996
	NG		0.082	Austrian data 2000
Wheat	11	0.084 (upper bound) 0.022 (lower bound)		German feed mills 1999
	13	0.140 (0.0002- 0.390; DM)		Schöppe and Kube-Schwickardi, 1996
	4	0.019 (0.005-0.052; DM)	0.021 (0.007-0.053; DM)	Malisch 2000
	NG	0.007 – 0.086		European Commission, 1999b
	Raw	0.020 (DM)		Kube and Schöppe 1998
	After sieving	0.011 (DM)		Kube and Schöppe 1998
	Wheat dust	0.440 (DM)		Kube and Schöppe 1998
	After cleaning	0.020 (DM)		Kube and Schöppe 1998
	5		0.010 – 0.087	Austrian data 2000
	NG		+ dust : 0.123	Austrian data 2000
Peas	NG		0.082	Austrian data 2000
Soya beans	NG	0.082		Austrian data 2000
	1	0.004	0.007	Malisch, 2000
Cereals and seeds	8		0.035 (0.004 – 0.182; DM)	Malisch, 2000
	NG		0.037 (0.007 – 0.184; DM)	Malisch, 2000

NG: not given

11.5. Table A5

Dioxin levels in by-products of milling

Feed	Number of samples	I-TEQ (ng /kg product or per kg dry matter)	WHO-TEQ (ng /kg product or per kg dry matter)	References
Oat bran	3	0.092 (upper bound) 0.033 (lower bound)		German feed mills 1999
Wheat bran	4	0.091 (upper bound) 0.034 (lower bound)		German feed mills 1999
	2	0.016 (0.014-0.017; DM)	0.021 (0.020-0.022; DM)	Malisch 2000
	NG	0.018 (DM)		Schöppe *et al*. 1997
	NG	0.038 (DM)		Kube and Schöppe 1998
	NG	0.040 – 0.100		European Commission, 1999b
	NG		0.082 – 0.100	Austrian data 2000
Milling By-products	10	0.671 (0.035-5.528 ; DM)		Ruoff *et al*. 1999
	9	0.153(without 5.528-value; DM)		

11.6. Table A6

Dioxin levels in by-products of starch industry

Feed	Number of samples	I-TEQ (ng /kg product or per kg dry matter)	WHO-TEQ (ng /kg product or per kg dry matter)	References
Corn gluten meal	4	0.089 (upper bound) 0.030 (lower bound)		German feed mills 1999
	3	0.130 (0.089 - 0.190; DM)		Schöppe and Kube-Schwickardi, 1996
	1	0.103 (DM)	0.113 (DM)	Malisch, 2000
	2		0.152 – 0.185	Austrian data 2000
Corn germ meal	NG	0.086 (upper bound) 0.023 (lower bound)		German feed mills 1999
Manioc	2	0.380 (0.050 – 0.710; DM)		Schöppe and Kube-Schwickardi, 1996

11.7. Table A7

Dioxin levels in by-products of sugar industry

Feed	Number of samples	I-TEQ (ng /kg product or per kg dry matter)	WHO-TEQ (ng /kg product or per kg dry matter)	References
Sugar beet pulp	4	0.096 (upper bound) 0.049 (lower bound)		German feed mills 1999
	NG	0.560 (DM)		Schöppe *et al.* 1997
	5	0.420 (0.120-0.550; DM)		European Commission, 1999b
	1	0.073 (DM)	0.077 (DM)	Malisch, 2000
	NG	0.220 – 0.340		Schöppe and Kube-Schwickardi, 1996
	3		0.197 – 0.300	Austrian data 2000
Molasses	NG	0.116 – 0.150		Schöppe and Kube-Schwickardi, 1996
Vinasse	NG		0.082	Austrian data 2000

11.8. Table A8

Dioxin levels in by-products of brewery/distillery

Feed	Number of samples	I-TEQ (ng /kg product or per kg dry matter)	WHO-TEQ (ng /kg product or per kg dry matter)	References
Citrus pulp	1	0.074 (upper bound) 0.016 (lower bound)		German feed mills 1999
	7	0.070 (0.042-0.122; DM)	0.078 (0.046-0.132; DM)	Malisch, 2000
	NG	0.073 (0.041 – 0.122; DM)		Traag *et al.* 1998
Malt sprouts	NG		0.233	Austrian data 2000
Yeast	1	0.106 (DM)	0.119 (DM)	Malisch, 2000
Brewers grain	1	0.120 (DM)	0.122 (DM)	Malisch, 2000

11.9. Table A9

Dioxin levels in by-products of oil industry and oils

Feed	Number of samples	I-TEQ (ng /kg product or per kg dry matter)	WHO-TEQ (ng /kg product or per kg dry matter)	References
Coconuts Cake	NG	0.088 (upper bound) 0.044 (lower bound)		German feed mills 1999
Line seed Meal	2	0.092 (upper bound) 0.039 (lower bound)		German feed mills 1999
Palm Kernel Meal	4	0.084 (upper bound) 0.030 (lower bound)		German feed mills 1999
	NG	0.069 (DM, Malaysia)		Schöppe and Kube-Schwickardi 1996
	1	0.038 (DM)	0.040 (DM)	Malisch, 2000
Rape Seed Meal	5	0.083 (upper bound) 0.021 (lower bound)		German feed mills 1999
	NG	0.420		Schöppe *et al.* 1997
	1	0.122 (DM)	0.132 (DM)	Malisch, 2000
	NG		0.002	Austrian data 2000
Rape seed Cake	1	0.014 (DM)	0.028 (DM)	Malisch, 2000
Soya bean Meal	2	0.049 (0.012-0.086; DM)	0.056 (0.016-0.096; DM)	Malisch, 2000
	7	0.082 (upper bound) 0.030 (lower bound)		German feed mills 1999
	NG	0.420 (DM)		Schöppe and Kube-Schwickardi, 1998
	NG		0.030	Austrian data 2000
Soya bean Shells	NG	0.105 (upper bound) 0.054 (lower bound)		German feed mills 1999
Sunflower Meal	4	0.099 (upper bound) 0.042 (lower bound)		German feed mills 1999
	2		0.04-0.084	Austrian data 2000
Byproducts of plant origin	19	0.064 (0.011 – 0.122)		Malisch, 2000
	NG		0.072 (0.016 – 0.132)	Malisch, 2000

11.10. Table A10

Dioxin levels in fish meal

Original data are presented in **bold** characters. Data in italics are calculated on the basis of the original data, either by multiplying or by dividing them by a factor of 5 to correct for the PCBs concentration. (See Chapter 4.2.2.1)

Material	Number of samples	I-TEQ (ng /kg fat)	WHO-TEQ (ng/kg fat)		References
			Dioxins only	Dioxins and PCBs	
Fish meal Pacific	8	**1.2 (0.18-2.1)**		*6 (0.9-10.5)*	Anon., 1999a
Fish meal Pacific	3	**1.1 (0.6-1.5)**		*5.5 (3-7.5)*	Anon., 2000
Fish meal/oil mixed, of Pacific and Europe origin	10		**0.5 (0.08-6.8)**	*2.5 (0.4-34)*	Döring, 2000
Fish meal Europe	32	**13.1 (1.0-47)**		*65.5 (5.0-235)*	Anon., 1999a
Fish meal Europe	5	**3.7 (0.3-6.8)**		*18.5 (1.5-34)*	Anon., 2000
Fish meal Europe	6		**8.3 (2.5-24)**	*41.5 (12.5-120)*	Lundebye-Haldorsen and Lie, 1999
Fish meal Europe (North)	7	**4.0 (1.0-11.3)**		*20 (5.0-56.5)*	Guomundsson, 1999, Audunssnon, 2000

11.11. Table A11

Dioxin levels in meat and bone meal

Material	Number of samples	I-TEQ (ng /kg product)	WHO-TEQ (ng /kg product)	References
Meat and bone meal	90		0.1-0.46	Industry
	2	0.2		Germany
	2	0.42		Germany
	NG	0.26-0.73		Schöppe *et al* 1997
	NG		0.096-0.3	Industry
	NG	0.07		France
	NG		0.17	Industry
	NG		0.15	Denmark
	NG	0.17		Germany
	NG	0.1-0.75		Schöppe *et al* 1997
Blood meal	NG		0.01-0.017	Industry
	2	0.14		Germany
Feather meal	NG	0.25		Germany
	4	0.02-0.73		France
	NG		0.255	Industry

11.12. Table A12

Dioxin levels in milk replacers

Material	Number of samples	I-TEQ (ng /kg DM)	WHO-TEQ (ng /kg DM)	References
Dried whey	NG	0.01		Germany
Refatted whey	NG		0.424 ng/kg fat	Industry
	NG		0.02-0.09	Industry
Milk replacer	2	0.65		Germany
Refatted milk	NG		0.5-0.74	Industry

11.13. Table A13

Dioxin levels in animal fat

Material	Number of samples	I-TEQ (ng /kg product)	WHO-TEQ (ng /kg product)	References
Animal fat	7		0.3	Austria
	2		0.225	Industry data
	17		3.3 (0.56-10.4)	Denmark
	5	1.08		Germany
	NG	0.8		Fürst 1998
	NG	0.06-1.2		Germany
	3		0.62	Denmark
	2	1.7-4.0		France
	NG	0.2-0.6		Malisch *et al* 1999
	NG	0.4-0.98		Ferrario *et al*
	NG	0.44		France
	NG		0.7	Denmark
	NG	0.2-2.3		Malisch *et al* 1999
	NG	0.4-1.1		Schöppe *et al* 1997
	NG	0.47		France
Mixed fat	3	0.66		Schöppe *et al*. 1997
	7	0.87		Ruoff *et al*. 1999
	13	0.95		Bosshammer, pers. Com
	20	2.02		Denmark
	37	2-3.3		Denmark
	17	3.3		Denmark
	5	1.1		Germany
Tallow	2	0.6-4.8		Kühn and Steeg 1993
	NG	0.9		Winters *et al*. 1996
	2	0.33-2.1		EU data
	20	4.13 (0.33-30.8)		Feil and Elis 1998
	NG	0.3-7.2		Malisch *et al* 1999
	2	0.225		Germany
	NG	0.57		France
	19		0.96 (0.54-20.2)	Denmark

11.14. Table A14

Dioxin levels in fish oil

Original data are presented in **bold** characters. Data in italics are calculated on the basis of the original data, either by multiplying or by dividing them by a factor of 5 to correct for the PCBs concentration. (see chapter 4.2.2.2)

Material	**Number of samples**	**I-TEQ (ng /kg fat)**	**WHO-TEQ (ng /kg fat)**		**References**
			Dioxins only	Dioxins and PCBs	
Fish oil Pacific	6	**0.95 (0.17-2.6)**		*4.75 (0.85-13)*	Anon., 1999a
Fish oil Pacific	5		*0.2 (0.16-0.4)*	**1.2 (0.8-1.9)**	Liem *et al.*, 1996
Fish oil Europe	40	**6.3 (1.0-20.1)**		*31.5 (5.0-100)*	Anon., 1999a
Fish oil Europe	2	**3.2 (1.7-4.6)**		*16 (8.5-23)*	Anon., 2000
Fish oil Europe	15	**3.5 (0.7-8.5) Nordic-TEQ**		***17.5 (3.5-42.5)***	Becher *et al.*, 1997 + unpubl. data
Fish oil Europe	6		*3.0 (1.1-5.2)*	**15 (5.7-25.8)**	Liem *et al.*, 1996
Fish oil Europe (North)	6		*5.6 (1.7-8.4)*	**28 (8.3-41.8)**	Vartiainen *et al.*, 1995, + unpubl. Data
Fish oil Europe (North)	17	**5.2 (1.4-6.8)**		*26 (7.0-34)*	Guomundsson, 1999, Audunssnon, 2000

11.15. Table A15

Dioxin levels in soil

Summary of dioxin concentrations in soil from EU Member States (ng I-TEQ/kg d.m.)

	Pasture	Arable	Rural	Forest	Others
Austria	1.6 – 14			<1 – 64	
Belgium			2.1 – 2.3		2.7 – 8.9
Finland	<1 – 30	<1 – 25	1 – 5	10 – 30	
Germany					<2 – 45
Greece	<1 – 13			4.8	<1 – 8.6
Ireland	<1 – 43	1.9 – 3.1			<1
Italy			1.4	6.0	1.8 – 20
Luxembourg			2.2 – 16		
The Netherlands			<1 – 8.4		<1 – 24.2
Spain			<1		
Sweden	<1 – 87		>1 – 20		
United Kingdom					

11.16. Table A16

Dioxin levels in binders, anticaking agents and coagulants

Material	Number of samples	I-TEQ (ng /kg product)	WHO-TEQ (ng /kg product)	References
Kaolinite	2			Austria
	20		166 (1-1132)	Germany
	3		0.63 (0.3-1.3)	Germany
	30		292 (5.3-1654)	Germany
	11		286.6(51.2-509.3)	Belgium
	3		32.8 (3.0-57.5)	United Kingdom
	6	150 (76-298)		France
	2	0.05-0.25		France
	4	0.062		France
	20	87 (4.8-240)		The Netherlands
	3	3.3-113		The Netherlands
	4	0.013-0.13		The Netherlands
	4	0.03-1.6		The Netherlands
	NG		16.7	Denmark
	5		0.25	Austria
Montmorillonite, bentonite	1	<0.02		USA
	1	1.4		Germany
	1	1.7		The Netherlands
	1	<1.9		The Netherlands
Zeolite	1		<4	The Netherlands
Clinoptilolite	4	0.017	0.1	European Commmission, 1999a
	NG		<0.05	European Commmission, 1999a
Steatite	NG		0.3	Austria
	NG		0.02-0.47	Austria
Sepiolite	4	0.29		The Netherlands
	5	0.23		Industry
	5	0.21		Industry
Lignosulfphonates	NG		0.01-0.53	United Kingdom
Silicic acid, colloidal silica	NG		0.08-0.12	Anonymous
Sodium aluminosilicate	NG		0.25	Anonymous

11.17. Table A17

Dioxin levels in minerals / trace elements

Material	Number of samples	I-TEQ (ng /kg product)	WHO-TEQ (ng /kg product)	References
Phosphates	NG		0.3-0.37	Austria
	NG		0.07	Austria
	NG	0.3		Germany
	NG		0.1	Austria
	2		0.3	Austria
	NG		0.01	Austria
	NG		0.08-0.2	European Commmission, 1999a
	7		0.1-0.3	Germany
Chalk	NG		0.049-0.082	Austria
	NG		0.4	Austria
	NG	0.19		The Netherlands
	NG	0.001-0.05		Germany
Salt	NG		0.05	Germany
	2	0.1		Germany
	NG	0.1		Austria
Ca sulphate	NG	0.19		The Netherlands
Mg oxide	NG		0.15	Germany
	4		1.2-2.3	Germany
	NG		0.27	Austria
Mg Fe silicate	NG	0.9		Germany
Zn oxide	NG		0.02	Austria

12. ANNEX B: CALCULATIONS

In this annex, some abbreviations are used because of the size of the tables:

Ax, Bx, C: The codes A1 to A5, B1 to B3, and C are used in accordance with their definintion in chapter 3

Comp: composition of the feedingstuff considered, expressed in percentage of dry matter

L: the calculation is based on the levels identified by SCAN as low for each feed material composing the diet

M: the calculation is based on the levels identified by SCAN as mean for each feed material composing the diet.

H: the calculation is based on the levels identified by SCAN as high, for each feed material composing the diet

Europe: feed materials originating from Europe

South Pacific: feed materials of fish origin (fish oil, fish meal) or concentrate containing such feed materials.

The distinction has been made between Europe and South Pacific (Peru and Chile according to the literature) feed materials of fish origin as literature shows difference in contamination by dioxins, which can impact on the total diet contamination, depending on the feed materials used and their geographic origin.

In the tables, the total contamination of the diets, under South Pacific, represents the sum of the value for the fish materials of Pacific origin (or in the case of ruminants for the concentrate IV) and of the values for the other diets components, which originate from Europe.

12.1. Ruminants

As most of the 20 examples of diets for ruminants involve mainly two different components: roughage and concentrate used at different ratios, the calculation has been done only with diets containing a different ratio roughage/concentrate.

Using a conservative approach, the Committee chose to use the levels of contamination identified for the Concentrate IV, for the calculation of the contamination of the different ruminants diets, although more appropriate concentrates may be used in practice depending on the type of production and on the feed materials available.

12.1.1. Concentrates - Tables B1 & B2

<u>Table B1</u> Estimation of the contamination of four different concentrates used in ruminants diets (expressed in ng WHO-TEQ/kg dry matter)

		Concentrate n°I				Concentrate n°II				Concentrate n°III							Concentrate n°IV						
		Comp	Europe			Comp	Europe			Comp	Europe			South Pacific			Comp	Europe			South Pacific		
	Feed materials	%	L	M	H	%	L	M	H	%	L	M	H	L	M	H	%	L	M	H	L	M	H
A3	Cereals & legumes	26	0.0026	0.0260	0.1040	55	0.0055	0.0550	0.2200	64	0.0064	0.0640	0.2560				62	0.0062	0.0620	0.2480			
A4	By-products	70	0.0140	0.0700	0.4900	39	0.0078	0.0390	0.2730	25	0.0050	0.0250	0.1750				25	0.0050	0.0250	0.1750			
B1	Fish meal	-				-				5	0.0020	0.0600	0.2800	0.0001	0.0004	0.0007	5	0.0020	0.0600	0.2800	0.0001	0.0004	0.0007
B2	Animal fat	-				2	0.0100	0.0200	0.0660	2	0.0100	0.0200	0.0660				4	0.0200	0.0400	0.1320			
C	Premix	4	0,0008	0,0080	0,0200	4	0,0008	0,0080	0,0200	4	0,0008	0,0080	0,0200				4	0.0008	0.0080	0.0200			
	TOTAL	100	0,0174	0,1040	0,6140	100	0,0241	0,1220	0,5790	100	0,0242	0,1770	0,7970	0,0223	0,1174	0,5177	100	0.0340	0.195	0.8550	0.0321	0.1354	0.5757

<u>Table B2</u> Estimation of the relative contribution of the different feed materials to the total contamination of four different concentrates used in ruminants diets (expressed in percentage of the concentrate contamination). The percentages are calculated on the basis of table B1.

		Concentrate n°I				Concentrate n°II				Concentrate n°III							Concentrate n°IV						
		Comp	Europe			Comp	Europe			Comp	Europe			South Pacific			Comp	Europe			South Pacific		
	Feed materials	%	L	M	H	%	L	M	H	%	L	M	H	L	M	H	%	L	M	H	L	M	H
A3	Cereals & legumes	26	15%	25%	17%	55	23%	45%	38%	64	26%	36%	32%	29%	55%	49%	62	18%	31%	29%	19%	46%	43%
A4	By-products	70	80%	67%	80%	39	32%	32%	48%	25	21%	14%	22%	22%	21%	34%	25	15%	13%	20%	16%	18%	30%
B1	Fish meal	-				-				5	8%	34%	35%	0%	0%	0%	5	6%	31%	34%	0%	0%	0%
B2	Animal fat	-				2	42%	16%	11%	2	42%	11%	8%	45%	17%	13%	4	59%	21%	15%	62%	30%	23%
C	Premix	4	5%	8%	3%	4	3%	7%	3%	4	3%	5%	3%	4%	7%	4%	4	2%	4%	2%	3%	6%	4%
	TOTAL	100	100%	100%	100%	100	100%	100%	100%	100	100%	100%	100%	100%	100%	100%	100	100%	100%	100%	100%	100%	100%

12.1.2. Dairy cattle diets - Tables B3 to B6

Table B3 Estimation of the contamination (expressed in ng WHO-TEQ/kg dry matter) of two different diets used in ruminants reared for dairy production, with a milk yield of 5-10 kg/day (diets also applicable to dry cows)

		Ruminant diet n°1				Ruminant diet n°2						
		Comp	Europe			Comp	Europe			South Pacific		
	Feed materials	%	L	M	H	%	L	M	H	L	M	H
A1	Roughage	100	0,1000	0,2000	6,6000	90	0,0900	0,1800	5,9400			
	Concentrate IV	-				10	0,0030	0,0200	0,0860	0,0030	0,0140	0,0580
	TOTAL	100	0,1000	0,2000	6,6000	100	0,0930	0,2000	6,0260	0,0930	0,1940	5,9980

Table B4 Estimation of the relative contribution of the different feed materials to the total contamination of two different diets in ruminants reared for dairy production, with a milk yield of 5-10 kg/day (diets also applicable to dry cows). The percentages are calculated on the basis of table B3.

		Ruminant diet n°1				Ruminant diet n°2						
		Comp	Europe			Comp	Europe			South Pacific		
	Feed materials	%	L	M	H	%	L	M	H	L	M	H
A1	Roughage	100	100%	100%	100%	90	97%	90%	99%	97%	93%	99%
	Concentrate IV	-				10	3%	10%	1%	3%	7%	1%
	TOTAL	100	100%	100%	100%	100	100%	100%	100%	100%	100%	100%

Table B5 Estimation of the contamination (expressed in ng WHO-TEQ/kg dry matter) of two different diets used in ruminants reared for milk production, with a milk yield of respectively 25-35 kg/day (diet n°4) and ≥40kg/day (diet n°5)

		Ruminant diet n°4							Ruminant diet n°5						
		Comp	Europe			South Pacific			Comp	Europe			South Pacific		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	L	M	H
A1	Roughage	60	0,0600	0,1200	3,9600				40	0,0400	0,0800	2,6400			
	Concentrate IV	40	0,0120	0,0800	0,3440	0,0120	0,0560	0,2320	60	0,0180	0,1200	0,5160	0,0180	0,0840	0,3480
	TOTAL	100	0,0720	0,2000	4,3040	0,0720	0,1760	4,1920	100	0,0580	0,2000	3,1560	0,0580	0,1640	2,9880

Table B6 Estimation of the relative contribution of the different feed materials to the total contamination of two different diets in ruminants reared for milk production, with a milk yield of respectively 25-35 kg/day (diet n°4) and ≥40kg/day (diet n°5). The percentages are calculated on the basis of table B5.

		Ruminant diet n°4							Ruminant diet n°5						
		Comp	Europe			South Pacific			Comp	Europe			South Pacific		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	L	M	H
A1	Roughage	60	83%	60%	92%	83%	68%	94%	40	69%	40%	84%	69%	49%	88%
	Concentrate IV	40	17%	40%	8%	17%	32%	6%	60	31%	60%	16%	31%	51%	12%
	TOTAL	100	100%	100%	100%	100%	100%	100%	100	100%	100%	100%	100%	100%	100%

12.1.3. Beef cattle diets - Tables B7 to B10

Table B7 Estimation of the contamination (expressed in ng WHO-TEQ/kg dry matter) of two different diets used in ruminants reared for beef production, with an average daily gain of respectively 400-800 g/day (diet n° 6) and 800-1200 g/day (diet n° 7)

		Ruminant diet n° 6							Ruminant diet n° 7						
		Comp	Europe			South Pacific			Comp	Europe			South Pacific		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	L	M	H
A1	Roughage	80	0,0800	0,1600	5,2800				75	0,0750	0,1500	4,9500			
	Concentrate IV	20	0,0060	0,0400	0,1720	0,0060	0,0280	0,1160	25	0,0075	0,0500	0,2150	0,0075	0,0350	0,1450
	TOTAL	100	0,0860	0,2000	5,4520	0,0860	0,1880	5,3960	100	0,0825	0,2000	5,1650	0,0825	0,1850	5,0950

Table B8 Estimation of the relative contribution of the different feed materials to the total contamination two different diets used in ruminants reared for beef production, with an average daily gain of respectively 400-800 g/day (diet n° 6) and 800-1200 g/day (diet n° 7). The percentages are calculated on the basis of table B7.

		Ruminant diet n° 6							Ruminant diet n° 7						
		Comp	Europe			South Pacific			Comp	Europe			South Pacific		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	L	M	H
A1	Roughage	80	93%	80%	97%	93%	85%	98%	75	91%	75%	96%	91%	81%	97%
	Concentrate IV	20	7%	20%	3%	7%	15%	2%	25	9%	25%	4%	9%	19%	3%
	TOTAL	100	100%	100%	100%	100%	100%	100%	100	100%	100%	100%	100%	100%	100%

Table B9 Estimation of the contamination (expressed in ng WHO-TEQ/kg dry matter) two different diets used in ruminants reared for beef production: average daily gain of >1200 g/day (diet n° 8) and feed lots (diet n° 9).

		Ruminant diet n° 8							Ruminant diet n° 9						
		Comp	Europe			South Pacific			Comp	Europe			South Pacific		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	L	M	H
A1	Roughage	70	0,0700	0,1400	4,6200				20	0,0200	0,0400	1,3200			
	Concentrate IV	30	0,0090	0,0600	0,2580	0,0090	0,0420	0,1740	80	0,0240	0,1600	0,6880	0,0240	0,1120	0,4640
	TOTAL	100	0,0790	0,2000	4,8780	0,0790	0,1820	4,7940	100	0,0440	0,2000	2,0080	0,0440	0,1520	1,7840

Table B10 Estimation of the relative contribution of the different feed materials to the total contamination two different diets used in ruminants reared for beef production: average daily gain of >1200 g/day (diet n° 8) and feed lots (diet n° 9). The percentages are calculated on the basis of table B9.

		Ruminant diet n° 8							Ruminant diet n° 9						
		Comp	Europe			South Pacific			Comp	Europe			South Pacific		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	L	M	H
A1	Roughage	70	89%	70%	95%	89%	77%	96%	20	45%	20%	66%	45%	26%	74%
	Concentrate IV	30	11%	30%	5%	11%	23%	4%	80	55%	80%	34%	55%	74%	26%
	TOTAL	100	100%	100%	100%	100%	100%	100%	100	100%	100%	100%	100%	100%	100%

12.1.4. Calves - Tables B11 & B12

Table B11 Estimation of the contamination (expressed in ng WHO-TEQ/kg dry matter) two different diets used in ruminants reared for beef production: average daily gain of >1200 g/day (diet n° 8) and feed lots (diet n° 9).

		Ruminant diet n° 10			
		Comp	Europe		
	Feed materials	%	L	M	H
A1	Roughage	10	0,0100	0,0200	0,6600
B5	Milk replacer	90	0,0540	0,1080	0,4320
	TOTAL	100	0,0640	0,1280	1,0920

Table B12 Estimation of the relative contribution of the different feed materials to the total contamination of two different diets in ruminants reared for dairy production, with a milk yield of 5-10 kg/day (diets also applicable to dry cows). The percentages are calculated on the basis of table B11.

		Ruminant diet n° 10			
		Comp	Europe		
	Feed materials	%	L	M	H
A1	Roughage	10	16%	16%	60%
B5	Milk replacer	90	84%	84%	40%
	TOTAL	100	100%	100%	100%

12.2. Pigs

12.2.1. Piglets - Tables B13 & B14

Table B13 Estimation of the contamination (expressed in ng WHO-TEQ/kg dry matter) of three different diets used in young pigs between one and two months of age.

		Pig diet n° 1							Pig diet n° 2							Pig diet n° 3						
		Comp	Europe			South Pacific			Comp	Europe			South Pacific			Comp	Europe			South Pacific		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	L	M	H	%	L	M	H	L	M	H
A3	Cereals & legumes	55	0.0055	0.0550	0.2200				59	0.0059	0.0590	0.2360				60	0.0060	0.0600	0.2400			
A4	By-products	36	0.0072	0.0360	0.2520				24	0.0048	0.0240	0.1680				33	0.0066	0.0330	0.2310			
B1	Fish meal	5	0.0020	0.0600	0.2800	0.0010	0.0070	0.0125	5	0.0020	0.0600	0.2800	0.0010	0.0070	0.0125	2	0.0008	0.0240	0.1120	0.0004	0.0028	0.0050
B2	Animal fat	-							8	0.0400	0.0800	0.2640				2	0.0100	0.0200	0.0660			
C	Premix	4	0.0008	0.0080	0.0200				4	0.0008	0.0080	0.0200				3	0.0006	0.0060	0.0150			
	TOTAL	100	0.0155	0.1590	0.7720	0.0145	0.1070	0.5045	100	0.0535	0.2310	0.9680	0.0525	0.1780	0.7005	100	0.0240	0.1430	0.6640	0.0236	0.1218	0.5570

Table B14 Estimation of the relative contribution of the different feed materials to the total contamination of three different diets used in young pigs between one and two months of age (expressed in percentage of the total diet contamination). The percentages are calculated on the basis of table B13

		Pig diet n° 1							Pig diet n° 2							Pig diet n° 3						
		Comp	Europe			South Pacific			Comp	Europe			South Pacific			Comp	Europe			South Pacific		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	L	M	H	%	L	M	H	L	M	H
A3	Cereals & legumes	55	35%	35%	28%	38%	52%	44%	59	11%	26%	24%	11%	33%	33%	60	25%	42%	36%	25%	49%	43%
A4	By-products	36	47%	23%	33%	50%	34%	50%	24	9%	10%	17%	9%	13%	24%	33	28%	23%	35%	28%	27%	41%
B1	Fish meal	5	13%	37%	36%	7%	7%	2%	5	4%	26%	29%	2%	4%	2%	2	3%	17%	17%	2%	2%	1%
B2	Animal fat	-							8	75%	35%	28%	76%	45%	38%	2	41%	14%	10%	42%	17%	12%
C	Premix	4	5%	5%	3%	5%	7%	4%	4	1%	3%	2%	2%	5%	3%	3	3%	4%	2%	3%	5%	3%
	TOTAL	100	100%	100%	100%	100%	100%	100%	100	100%	100%	100%	100%	100%	100%	100	100%	100%	100%	100%	100%	100%

12.2.2. Pigs for fattening – Tables B15 & B16

Table B15 Estimation of the contamination (expressed in ng WHO-TEQ/kg dry matter) of five different diets used in pigs for fattening.

		Pig diet n° 4				Pig diet n° 5				Pig diet n° 6				Pig diet n° 7				Pig diet n° 8			
		Comp	Europe			Comp	Europe			Comp	Europe			Comp	Europe			Comp	Europe		
	Feed materials	%	L	M	H	%	L	M	H	%	L	M	H	%	L	M	H	%	L	M	H
A3	Cereals & legumes	74	0.0074	0.0740	0.2960	40	0.0040	0.0400	0.1600	80	0.0080	0.0800	0.3200	69	0.0069	0.0690	0.2760	61	0.0061	0.0610	0.2440
A4	By-products	23	0.0046	0.0230	0.1610	53	0.0106	0.0530	0.3710	17	0.0034	0.0170	0.1190	23	0.0046	0.0230	0.1610	29	0.0058	0.0290	0.2030
B2	Animal fat	-				4	0.0200	0.0400	0.1320	-				5	0.0250	0.0500	0.1650	4	0.0200	0.0400	0.1320
B2	Meat and bone meal	-				-				-				-				5	0.0050	0.0100	0.0250
C	Premix	3	0.0006	0.0060	0.0150	3	0.0006	0.0060	0.0150	3	0.0006	0.0060	0.0150	3	0.0006	0.0060	0.0150	1	0.0002	0.0020	0.0050
	TOTAL	100	0.0126	0.1030	0.4720	100	0.0352	0.1390	0.6780	100	0.0120	0.1030	0.4540	100	0.0371	0.1480	0.6170	100	0.0371	0.1420	0.6090

Table B16 Estimation of the relative contribution of the different feed materials to the total contamination of three different diets used in pigs for fattening (expressed in percentage of the total diet contamination). The percentages are calculated on the basis of table B15.

		Pig diet n° 4				Pig diet n° 5				Pig diet n° 6				Pig diet n° 7				Pig diet n° 8			
		Comp	Europe			Comp	Europe			Comp	Europe			Comp	Europe			Comp	Europe		
	Feed materials	%	L	M	H	%	L	M	H	%	L	M	H	%	L	M	H	%	L	M	H
A3	Cereals & legumes	74	58%	72%	63%	40	11%	29%	24%	80	67%	77%	71%	69	19%	46%	45%	61	16%	44%	40%
A4	By-products	23	37%	22%	34%	53	30%	38%	55%	17	28%	17%	26%	23	12%	16%	26%	29	16%	20%	33%
B2	Animal fat	-				4	57%	29%	19%	-				5	67%	34%	27%	4	54%	28%	22%
B2	Meat and bone meal	-				-				-				-				5	13%	7%	4%
C	Premix	3	5%	6%	3%	3	2%	4%	2%	3	5%	6%	3%	3	2%	4%	2%	1	1%	1%	1%
	TOTAL	100	100%	100%	100%	100	100%	100%	100%	100	100%	100%	100%	100	100%	100%	100%	100	100%	100%	100%

12.2.3. Sows

12.2.3.1. Lactating sows – Tables B17 & B18

Table B17 Estimation of the contamination (expressed in ng WHO-TEQ/kg dry matter) of three different diets used in lactating sows.

		Pig diet n° 9							**Pig diet n° 10**							**Pig diet n° 11**			
		Comp	**Europe**			**South Pacific**			**Comp**	**Europe**			**South Pacific**			**Comp**	**Europe**		
	Feed materials	**%**	**L**	**M**	**H**	**L**	**M**	**H**	**%**	**L**	**M**	**H**	**L**	**M**	**H**	**%**	**L**	**M**	**H**
A3	**Cereals & legumes**	**79**	**0.0079**	**0.0790**	**0.3160**				**58**	**0.0058**	**0.0580**	**0.2320**				**55**	**0.0055**	**0.0550**	**0.2200**
A4	**By-products**	**15**	**0.0030**	**0.0150**	**0.1050**				**31**	**0.0062**	**0.0310**	**0.2170**				**39**	**0.0078**	**0.0390**	**0.2730**
B1	**Fish meal**	**2**	**0.0008**	**0.0240**	**0.1120**	**0.0004**	**0.0028**	**0.0050**	**2**	**0.0008**	**0.0240**	**0.1120**	**0.0004**	**0.0028**	**0.0050**	**-**			
B2	**Animal fat**	**-**							**5**	**0.0250**	**0.0500**	**0.1650**				**3**	**0.0150**	**0.0300**	**0.0990**
C	**Premix**	**4**	**0.0008**	**0.0080**	**0.0200**				**4**	**0.0008**	**0.0080**	**0.0200**				**3**	**0.0006**	**0.0060**	**0.0150**
	TOTAL	**100**	**0.0125**	**0.1260**	**0.5530**	**0.0121**	**0.1048**	**0.4460**	**100**	**0.0386**	**0.1710**	**0.7460**	**0.0382**	**0.1498**	**0.6390**	**100**	**0.0289**	**0.1300**	**0.6070**

Table B18 Estimation of the relative contribution of the different feed materials to the total contamination of three different diets used in lactating sows (expressed in percentage of the total diet contamination). The percentages are calculated on the basis of table B17.

		Pig diet n° 9							**Pig diet n° 10**							**Pig diet n° 11**			
		Comp	**Europe**			**South Pacific**			**Comp**	**Europe**			**South Pacific**			**Comp**	**Europe**		
	Feed materials	**%**	**L**	**M**	**H**	**L**	**M**	**H**	**%**	**L**	**M**	**H**	**L**	**M**	**H**	**%**	**L**	**M**	**H**
A3	**Cereals & legumes**	**79**	**64%**	**63%**	**57%**	**65%**	**75%**	**71%**	**58**	**15%**	**34%**	**31%**	**15%**	**39%**	**36%**	**55**	**19%**	**42%**	**36%**
A4	**By-products**	**15**	**24%**	**12%**	**19%**	**25%**	**14%**	**24%**	**31**	**16%**	**18%**	**29%**	**16%**	**21%**	**34%**	**39**	**27%**	**30%**	**46%**
B1	**Fish meal**	**2**	**6%**	**19%**	**20%**	**3%**	**3%**	**1%**	**2**	**2%**	**14%**	**15%**	**1%**	**2%**	**1%**	**-**			
B2	**Animal fat**	**-**							**5**	**65%**	**29%**	**22%**	**66%**	**33%**	**26%**	**3**	**52%**	**23%**	**16%**
C	**Premix**	**4**	**6%**	**6%**	**4%**	**7%**	**8%**	**4%**	**4**	**2%**	**5%**	**3%**	**2%**	**5%**	**3%**	**3**	**2%**	**5%**	**2%**
	TOTAL	**100**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100**	**100%**	**100%**	**100%**

12.2.3.2. Pregnant sows – Tables B19 & B20

Table B19 Estimation of the contamination (expressed in ng WHO-TEQ/kg dry matter) of three different diets used in pregnant sows.

		Pig diet n° 12				Pig diet n° 13				Pig diet n° 14			
		Comp	Europe			Comp	Europe			Comp	Europe		
	Feed materials	%	L	M	H	%	L	M	H	%	L	M	H
A1	Roughage	-				-				32	0.0320	0.0640	2.1120
A3	Cereals & legumes	54	0.0054	0.0540	0.2160	29	0.0029	0.0290	0.1160	25	0.0025	0.0250	0.1000
A4	By-products	43	0.0086	0.0430	0.3010	64	0.0128	0.0640	0.4480	40	0.0080	0.0400	0.2800
B2	Animal fat	-				5	0.0250	0.0500	0.1650	1	0.0050	0.0100	0.0330
C	Premix	3	0.0006	0.0060	0.0150	2	0.0004	0.0040	0.0100	2	0.0004	0.0040	0.0100
	TOTAL	100	0.0146	0.1030	0.5320	100	0.0411	0.1470	0.7390	100	0.0479	0.1430	2.5350

Table B20 Estimation of the relative contribution of the different feed materials to the total contamination of three different diets used in pregnant sows (expressed in percentage of the total diet contamination). The percentages are calculated on the basis of table B19.

		Pig diet n° 12				Pig diet n° 13				Pig diet n° 14			
		Comp	Europe			Comp	Europe			Comp	Europe		
	Feed materials	%	L	M	H	%	L	M	H	%	L	M	H
A1	Roughage	-				-				32	67%	45%	84%
A3	Cereals & legumes	54	37%	52%	41%	29	7%	20%	16%	25	5%	17%	4%
A4	By-products	43	59%	42%	56%	64	31%	43%	61%	40	17%	28%	11%
B2	Animal fat	-				5	61%	34%	22%	1	10%	7%	1%
C	Premix	3	4%	6%	3%	2	1%	3%	1%	2	1%	3%	0%
	TOTAL	100	100%	100%	100%	100	100%	100%	100%	100	100%	100%	100%

12.3. Poultry

12.3.1. Broilers - Tables B21 & B22

Table B21 Estimation of the contamination (expressed in ng WHO-TEQ/kg dry matter) of three different diets used for broilers.

		Poultry diet n°1							Poultry diet n°2				Poultry diet n°3			
		Comp	Europe			South Pacific			Comp	Europe			Comp	Europe		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	%	L	M	H
A3	Cereals & legumes	58	0.0058	0.0580	0.2320				70	0.0070	0.0700	0.2800	55	0.0055	0.0550	0.2200
A4	By-products	30	0.0060	0.0300	0.2100				18	0.0036	0.0180	0.1260	31	0.0062	0.0310	0.2170
B1	Fish meal	5	0.0020	0.0600	0.2800	0.0010	0.0070	0.0125	-				-			
B2	Animal fat	3	0.0150	0.0300	0.0990				5	0.0250	0.0500	0.1650	10	0.0500	0.1000	0.3300
B2	Meat and bone meal	-							3	0.0030	0.0060	0.0150	-			
C	Premix	4	0.0008	0.0080	0.0200				4	0.0008	0.0080	0.0200	4	0.0008	0.0080	0.0200
	TOTAL	100	0.0296	0.1860	0.8410	0.0286	0.1330	0.5735	100	0.0394	0.1520	0.6060	100	0.0625	0.1940	0.7870

Table B22 Estimation of the relative contribution of the different feed materials to the total contamination of three different diets used for broilers (expressed in percentage of the total diet contamination). The percentages are calculated on the basis of table B21.

		Poultry diet n°1							Poultry diet n°2				Poultry diet n°3			
		Comp	Europe			South Pacific			Comp	Europe			Comp	Europe		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	%	L	M	H
A3	Cereals & legumes	58	20%	31%	28%	20%	44%	40%	70	18%	46%	46%	55	9%	28%	28%
A4	By-products	30	20%	16%	25%	21%	22%	37%	18	9%	12%	21%	31	10%	16%	27%
B1	Fish meal	5	7%	33%	33%	4%	5%	2%	-				-			
B2	Animal fat	3	50%	16%	12%	52%	23%	17%	5	63%	33%	27%	10	80%	52%	42%
B2	Meat and bone meal	-							3	8%	4%	3%	-			
C	Premix	4	3%	4%	2%	3%	6%	4%	4	2%	5%	3%	4	1%	4%	3%
	TOTAL	100	100%	100%	100%	100%	100%	100%	100	100%	100%	100%	100	100%	100%	100%

12.3.2. Layers – Tables B23 & B24

Table B23 Estimation of the contamination (expressed in ng WHO-TEQ/kg dry matter) of three different diets used for layers.

		Poultry diet n°4							Poultry diet n°5				Poultry diet n°6			
		Comp	Europe			South Pacific			Comp	Europe			Comp	Europe		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	%	L	M	H
A1	Roughage	3	0.0030	0.0060	0.1980				3	0.0030	0.0060	0.1980	5	0.0050	0.0100	0.3300
A3	Cereals & legumes	70	0.0070	0.0700	0.2800				60	0.0060	0.0600	0.2400	60	0.0060	0.0600	0.2400
A4	By-products	15	0.0030	0.0150	0.1050				26	0.0052	0.0260	0.1820	24	0.0048	0.0240	0.1680
B1	Fish meal	3	0.0012	0.0360	0.1680	0.0006	0.0042	0.0075	-				-			
B2	Animal fat	-							-				2	0.0100	0.0200	0.0660
B2	Meat and bone meal	-							3	0.0030	0.0060	0.0150	-			
C	Limestone	7	0.0070	0.0140	0.0350				6	0.0060	0.0120	0.0300	7	0.0070	0.0140	0.0350
C	Premix	2	0.0004	0.0040	0.0100				2	0.0004	0.0040	0.0100	2	0.0004	0.0040	0.0100
	TOTAL	100	0.0216	0.1450	0.7960	0.0210	0.1132	0.6355	100	0.0236	0.1140	0.6750	100	0.0332	0.1320	0.8490

Table B24 Estimation of the relative contribution of the different feed materials to the total contamination of three different diets used for layers (expressed in percentage of the total diet contamination). The percentages are calculated on the basis of table B23.

		Poultry diet n°4							Poultry diet n°5				Poultry diet n°6			
		Comp	Europe			South Pacific			Comp	Europe			Comp	Europe		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	%	L	M	H
A1	Roughage	3	14%	4%	25%	14%	5%	31%	3	13%	5%	29%	5	15%	8%	39%
A3	Cereals & legumes	70	32%	48%	36%	34%	62%	44%	60	25%	52%	37%	60	18%	45%	28%
A4	By-products	15	14%	10%	13%	14%	13%	17%	26	22%	23%	27%	24	14%	18%	20%
B1	Fish meal	3	6%	25%	21%	3%	4%	1%	-				-			
B2	Animal fat	-							-				2	31%	15%	8%
B2	Meat and bone meal	-							3	13%	5%	2%	-			
C	Limestone	7	32%	10%	4%	33%	12%	5%	6	25%	11%	4%	7	21%	11%	4%
C	Premix	2	2%	3%	1%	2%	4%	2%	2	2%	4%	1%	2	1%	3%	1%
	TOTAL	100	100%	100%	100%	100%	100%	100%	100	100%	100%	100%	100	100%	100%	100%

12.3.3. Turkeys – Tables B25 & B26

Table B25 Estimation of the contamination (expressed in ng WHO-TEQ/kg dry matter) of three different diets used for turkeys.

		Poultry diet n°7							Poultry diet n°8				Poultry diet n°9			
		Comp	Europe			South Pacific			Comp	Europe			Comp	Europe		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	%	L	M	H
A3	Cereals & legumes	47	0.0047	0.0470	0.1880				60	0.0060	0.0600	0.2400	55	0.0055	0.0550	0.2200
A4	By-products	45	0.0090	0.0450	0.3150				30	0.0060	0.0300	0.2100	34	0.0068	0.0340	0.2380
B1	Fish meal	3	0.0012	0.0360	0.1680	0.0006	0.0042	0.0075	-				-			
B2	Animal fat	2	0.0100	0.0200	0.0660				4	0.0200	0.0400	0.1320	8	0.0400	0.0800	0.2640
B2	Meat and bone meal	-							3	0.0030	0.0060	0.0150	-			
C	Premix	3	0.0006	0.0060	0.0150				3	0.0006	0.0060	0.0150	3	0.0006	0.0060	0.0150
	TOTAL	100	0.0255	0.1540	0.7520	0.0249	0.1222	0.5915	100	0.0356	0.1420	0.6120	100	0.0529	0.1750	0.7370

Table B26 Estimation of the relative contribution of the different feed materials to the total contamination of three different diets used for turkeys (expressed in percentage of the total diet contamination). The percentages are calculated on the basis of table B25.

		Poultry diet n°7							Poultry diet n°8				Poultry diet n°9			
		Comp	Europe			South Pacific			Comp	Europe			Comp	Europe		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	%	L	M	H
A3	Cereals & legumes	47	18%	31%	25%	19%	39%	32%	60	17%	43%	40%	55	10%	31%	30%
A4	By-products	45	35%	29%	42%	36%	37%	53%	30	17%	21%	34%	34	13%	19%	32%
B1	Fish meal	3	5%	23%	22%	2%	3%	1%	-				-			
B2	Animal fat	2	39%	13%	9%	41%	16%	11%	4	56%	28%	22%	8	76%	47%	36%
B2	Meat and bone meal	-							3	8%	4%	2%	-			
C	Premix	3	3%	4%	2%	2%	5%	3%	3	2%	4%	2%	3	1%	3%	2%
	TOTAL	100	100%	100%	100%	100%	100%	100%	100	100%	100%	100%	100	100%	100%	100%

12.4. Rabbits – Tables B27 & B28

Table B27 Estimation of the contamination (expressed in ng WHO-TEQ/kg dry matter) of three different diets used for rabbits. Two for rabbits for fattening (diets n° 1 and 2) and one for reproductive doe (diet n°3)

		Rabbits diet n°1				Rabbits diet n°2				Rabbits diet n°3			
		Comp	Europe			Comp	Europe			Comp	Europe		
	Feed materials	%	L	M	H	%	L	M	H	%	L	M	H
A1	Roughage	20	0.0200	0.0400	1.3200	18	0.0180	0.0360	1.1880	18	0.0180	0.0360	1.1880
A3	Cereals & legumes	25	0.0025	0.0250	0.1000	29	0.0029	0.0290	0.1160	33	0.0033	0.0330	0.1320
A4	By-products	50	0.0100	0.0500	0.3500	44	0.0088	0.0440	0.3080	44	0.0088	0.0440	0.3080
B2	Animal fat	1	0.0050	0.0100	0.0330	5	0.0250	0.0500	0.1650	1	0.0050	0.0100	0.0330
C	Premix	4	0.0008	0.0080	0.0200	4	0.0008	0.0080	0.0200	4	0.0008	0.0080	0.0200
	TOTAL	100	0.0383	0.1330	1.8230	100	0.0555	0.1670	1.7970	100	0.0359	0.1310	1.6810

Table B28 Estimation of the relative contribution of the different feed materials to the total contamination of three different diets used for rabbits (expressed in percentage of the total diet contamination). The percentages are calculated on the basis of table B27.

		Rabbits diet n°1				Rabbits diet n°2				Rabbits diet n°3			
		Comp	Europe			Comp	Europe			Comp	Europe		
	Feed materials	%	L	M	H	%	L	M	H	%	L	M	H
A1	Roughage	20	52%	30%	73%	18	33%	22%	67%	18	50%	27%	71%
A3	Cereals & legumes	25	7%	19%	5%	29	5%	17%	6%	33	9%	25%	8%
A4	By-products	50	26%	37%	19%	44	16%	26%	17%	44	25%	34%	18%
B2	Animal fat	1	13%	8%	2%	5	45%	30%	9%	1	14%	8%	2%
C	Premix	4	2%	6%	1%	4	1%	5%	1%	4	2%	6%	1%
	TOTAL	100	100%	100%	100%	100	100%	100%	100%	100	100%	100%	100%

12.5. Fish – Tables B29 & B30

Table B29 Estimation of the contamination (expressed in ng WHO-TEQ/kg dry matter) of the typical diets for omnivorous and carnivorous fish species.

		Diet for omnivorous species							Diet for carnivorous species						
		Comp	Europe			South Pacific			Comp	Europe			South Pacific		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	L	M	H
A3	Cereals & legumes	30	0.0030	0.0300	0.1200				11	0.0011	0.0110	0.0440			
A4	By-products	56	0.0112	0.0560	0.3920				12	0.0024	0.0120	0.0840			
B1	Fish meal	10	0.0040	0.1200	0.5600	0.0020	0.0140	0.0250	50	0.0200	0.6000	2.8000	0.0100	0.0700	0.1250
B1	Fish oil	2	0.0140	0.0960	0.4000	0.0032	0.0122	0.0520	25	0.1750	1.2000	5.0000	0.0400	0.1525	0.6500
C	Premix	2	0.0004	0.0040	0.0100				2	0.0004	0.0040	0.0100			
	TOTAL	100	0.0326	0.3060	1.4820	0.0198	0.1162	0.5990	100	0.1989	1.8270	7.9380	0.0539	0.2495	0.9130

Table B30 Estimation of the relative contribution of the different feed materials to the total contamination of the typical diets for omnivorous and carnivorous fish species (expressed in percentage of the total diet contamination). The percentages are calculated on the basis of table B29.

		Diet for omnivorous species							Diet for carnivorous species						
		Comp	Europe			South Pacific			Comp	Europe			South Pacific		
	Feed materials	%	L	M	H	L	M	H	%	L	M	H	L	M	H
A3	Cereals & legumes	30	9%	10%	8%	15%	26%	20%	11	1%	1%	1%	2%	4%	5%
A4	By-products	56	34%	18%	26%	57%	48%	65%	12	1%	1%	1%	4%	5%	9%
B1	Fish meal	10	12%	39%	38%	10%	12%	4%	50	10%	33%	35%	19%	28%	14%
B1	Fish oil	2	44%	32%	27%	16%	11%	9%	25	88%	65%	63%	74%	61%	71%
C	Premix	2	1%	1%	1%	2%	3%	2%	2	0%	0%	0%	1%	2%	1%
	TOTAL	100	100%	100%	100%	100%	100%	100%	100	100%	100%	100%	100%	100%	100%